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A

SYSTEM OF SURGERY,

THEORETICAL AND PRACTICAL.

IN

TREATISES BY VARIOUS AUTHORS.

EDITED BY

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FIRST AMERICAN, FROM SECOND ENGLISH EDITION,

THOROUGHLY REVISED AND MUCH ENLARGED,

BY

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ASSISTED BY

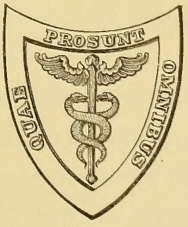
A LARGE CORPS OF THE MOST EMINENT AMERICAN SURGEONS.

IN THREE VOLUMES,

WITH MANY ILLUSTRATIONS.

VOL. I.

GENERAL PATHOLOGY. MORBID PROCESSES. INJURIES IN GENERAL. COMPLICATIONS OF INJURIES. INJURIES OF REGIONS.



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COLLINS, PRINTER.

PREFACE

TO THE

AMERICAN EDITION.

The high position universally accorded to Holmes's "System of Surgery" has rendered it very desirable that this work, containing in itself a vast store of the learning and experience of some of Great Britain's best surgeons, should be made more available to the profession in this country; and that the new material accumulated on both sides of the Atlantic, in the ten years which have elapsed since its publication, should be incorporated with it.

Under these circumstances, the present Publishers desired to place the work of preparing a new edition in my hands. Accepting the task, not without much diffidence, I was glad to find that the undertaking met with almost unanimous approval, and to secure, for the editing of special articles, the co-operation of men whose names are a sufficient guarantee of the able and faithful discharge of that duty.

The text of the last English edition has been reproduced, unaltered and unabridged, with two exceptions to be presently noted; the comments or additions of the Editors having been simply interpolated, inclosed in brackets. The exceptions were: the article on Diseases of the Skin, and that on Affections of the Absorbent System. Upon careful examination, it was found that a great portion of the former, and the whole of the latter, could scarcely be dealt with satisfactorily by any process of editing, and it was therefore resolved to have them re-written by competent hands.

Some changes of arrangement have been made, the subjects being grouped more conveniently than in the English edition, and the material has been divided into three volumes instead of five. A few words may perhaps be appropriately said in explanation of the new arrangement adopted: Volume I. will contain subjects belonging to general surgery and injuries of regions. In Volume II., and the first part of

Volume III., will be found the diseases of the various systems and organs, and the concluding portion will be devoted again to general practical matters—operative and minor surgery, gunshot wounds, hospitals, and some topics not readily classified. It is believed that an examination of the plan thus briefly sketched will show it to be not only philosophical but extremely simple and convenient. One special advantage of this rearrangement is, that it admits of general titles on the back of each volume, by means of which the place of any subject will be at once indicated. Moreover, with a copious index at the end of each volume, and a more general one at the conclusion of the whole work, the reader will find the labor of reference to any special point greatly facilitated, and the practical value of the book proportionately increased. The appendix to the article on Inflammation, which in the original was unavoidably placed nearly at the end of the whole book, has been added to the article itself in the first volume.

With regard to Anæsthetics, it is well known that in England chloroform has been, at least until within a few years past, much more generally used than in this country, where the majority of surgeons have preferred sulphuric ether, on account of its greater safety. It has not been thought needful to note this everywhere through the book when chloroform is mentioned, but the reader will probably make the substitution or not, according to his individual views on the subject. The original article on anæsthetics has been allowed to stand, but with an appendix from the pen of Dr. J. C. Reeve, of Dayton, Ohio, well known as an authority in this matter.

The illustrations of the original work have been almost without exception reproduced, and a very large number have been added. The aim of the Publishers has been to omit no available aid of this kind which could increase the value of the text.

As of necessity, the amount of material inserted by the Editors will be found to vary greatly in the different articles. Some were, upon careful revision, found to be wholly up to the present time, and in entire accord with the views and practice of American Surgeons. Others, from the nature of their subjects, required copious annotation. My earnest effort, as the Editor-in-chief, has been to adapt the work, as thoroughly as possible, to the wants of the reading and practising surgeons of this country.

JOHN H. PACKARD.

PREFACE

TO THE

SECOND ENGLISH EDITION.

The second edition of this work will not be found to differ essentially in plan and arrangement from the first. Some changes have been made in the order in which the essays are placed, and the matter of each essay has been revised, so as to bring the work as far as possible up to the latest time, both in authorized teaching and practice; but the work remains in the main unchanged. The want of illustrations has been felt as a practical hindrance to its usefulness, and this want the Publishers, at the instance of the Editor, have determined to supply, as far as it could be done, without unduly increasing the cost of the book. The aim of the Editor and Contributors has been to supply illustrations which would be of real service, either in making the text intelligible, or in assisting the diagnosis of disease.

On one important subject a deviation from the natural arrangement has been found necessary: viz., the Pathology of Inflammation. The recent researches of Cohnheim and others have thrown so much doubt upon the accepted theories on this matter, and these researches were published so near to the time when the essay on Inflammation was required for the press, that it became necessary either to delay the publication of the whole until reasonable time had been given to test these authors' statements, or to postpone the pathological section of the essay on Inflammation until the completion of the work. For many reasons, the latter course seemed preferable; but it entails the inconvenience that the chapter on Inflammation will be found to be contained partly in the first volume and partly in the fifth.

In conclusion, the Editor has only to acknowledge gratefully, the favor with which the original work has been received, and to hope that this re-issue of it may deserve and obtain an equally favorable reception.

T. HOLMES.

PREFACE

TO THE

FIRST ENGLISH EDITION.

The object of this book is to unite into a complete system the opinions and experience of many men, most of them Hospital Surgeons in London, and most of them writing on subjects of their own choice. As each subject must be treated with something of the completeness of a monograph, the work must necessarily be voluminous; but both Contributors and Editor have done their best to present each essay in as moderate a compass as the topic would allow. Where so many men unite in writing on parts of one great subject, it is hardly possible to avoid some differences of opinion; but none of much importance will, it is hoped, be detected in the following pages, and certainly none which can destroy the uniformity of the teaching.

The arrangement adopted in this work is as follows:—

I. The diseases which affect the whole system are first described, and this part comprises the essays ending with that on Cancer.

II. The next part treats of injuries which either involve the whole or a large part of the body, or which may be met with in any region. This extends to the end of the essay on Gunshot Wounds, in the second volume. These two parts comprise the whole subject of Surgical Pathology.

III. The various local injuries are next described; and in this part the anatomical order has been followed, the body having been divided into eight regions—the Head, Face, Neck, Thorax, Back, Pelvis, Upper and Lower Extremity. By this plan it was thought that the injuries which affect the same parts, and which in practice have to be diagnosed from each other, would be brought into the same part of the book and under the treatment of the same author.

IV. The principles of operative and minor Surgery, and of the employment of anæsthetics, follow the essays on local injuries.

V. The next part comprises the surgical diseases of the various organs of the body. These have been arranged according to the function of the parts affected: as diseases of the organs of special sense—the Eye, Ear,

and Nose; of the organs of locomotion—the Bones, Joints, Muscles, Tendons, and their Sheaths, etc.

VI. An Appendix completes the work, comprising the Principles of Surgical Diagnosis, of the Surgical Pathology and Treatment of Children's Diseases, the Construction and Management of Hospitals, and various miscellaneous matters which it was found difficult to bring under any of the previous heads.

This arrangement has been chosen, not as being free from objections, but as the best which suggested itself. The principal objection, perhaps, is the difficulty of separating the direct effects of injury from those diseases which frequently result from injury; but it is hoped that it will be found to have the merit of being intelligible, and of not making unnecessary artificial separations between things nearly connected in practice.

Any difficulty which may be found in discovering the place of any subject will be met by the analytical Tables of Contents at the head of each volume, and the copious Index at the end of the work.

For the plan of the work the Editor must be held responsible; the opinions expressed in each separate essay rest upon the authority of the writer, whose name is signed to it.

The Editor must express his deep sense of the honor done him in selecting him for the important task of preparing this book and seeing it through the press. He has endeavored to discharge his difficult duties to the best of his ability; had it not been for the unfailing courtesy and willing co-operation which he has experienced from all the Contributors, it would have been impossible to perform them at all; nor could the scheme have ever been realized but for the energy and liberality of the Messrs. Parker. The Editor, as well as all connected with it, have to lament, in the premature death of Mr. Parker, Junior, one who was warmly interested in the success of this undertaking, whose friendship the Editor was happy enough to form in consequence of their common connection with it, and from whom he constantly received valuable advice and encouragement.

T. HOLMES.

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PART I.

GENERAL PATHOLOGY.

INFLAMMATION.

HECTIC AND TRAUMATIC FEVER.

COLLAPSE.

SCROFULA.

SYPHILIS.

TUMORS AND CANCER.

TUMORS.

CANCER.

MICROSCOPICAL STRUCTURE OF TUMORS AND CANCER.

A SYSTEM OF SURGERY.

PART I.

GENERAL PATHOLOGY.

INFLAMMATION.

By John Simon, Esq., F.R.S., and J. Burdon-Sanderson, Esq., M.D., F.R.S.

Revised by J. Henry C. Simes, M.D.

The purpose of the present article is to consider generally the Pathology and Treatment of Inflammation.

In those sections of the work which refer to diseases and injuries of particular organs, there will be better opportunity for discussing how far this or that organ, when inflamed, gives distinctive characters to the inflammation affecting it, or requires that such inflammation should be treated by peculiar means. In the present essay, therefore, such "local specialities" of the subject will be but lightly touched upon; only so far, indeed, as may be necessary to illustrate general statements, or to render them correct and complete. Thus, for instance, the student who wishes to learn all that may practically aid him with reference to the diagnosis or treatment of ophthalmia or of synovitis will refer to those after-pages in which Diseases of the Eye and Diseases of the Joints are considered. Likewise what relates to "specific varieties" of inflammation may be more advantageously studied in the sections which are devoted to Syphilis, Scrofula, Carbuncle, Erysipelas, and other like subjects. Even the so-called "terminations" of inflammation will not be exhaustively considered in this general article; for many of the facts connected with them can, at least for practical purposes, be more conveniently classed under such special heads as those of Abscess, Ulcer, and Gangrene.

Notwithstanding these limitations, the present subject is of large scope and of equally large importance. To the student whose acquaintance with it is first beginning, it seems to branch almost throughout the whole subject-matter of surgery. Nor does a more critical inquiry tend very greatly to abate this first impression. For among the infinite varieties of surgical casualty and disease, singularly few are the cases which do not at some moment of their course—either in their origin, or in their complications, or in their treatment, involve an appeal to those laws of textural irritability which govern the phenomena of inflammation. And it is no exaggeration to say, that rational surgery depends more upon a knowledge of the inflammatory process than upon all other pathological knowledge put together.

Etymology.—The word "inflammation" is a very old one. That burnt or wounded external parts are apt to become hot, red, painful, and swollen, must have been among the first observations of mankind. The increased heat of the injured part, or the sufferer's feeling of increased heat in it, seems especially to have fixed popular attention; and thus, however far back in time we trace the nomenclature of disease, always we find that such words as our "inflammation"—deriv. *flamma*, φλέγμα, φλέγειν—words which denote the physical fact of *having been set on fire*, have been used with regard to textures of the living body, in order to express that peculiar morbid change which external injury excites in them.[1]

[1] Every one who reads the German language will recognize that the above statement applies to it (in respect of its word *Entzün-*

But such words have not, in their application, been restricted to the results of local injury. So far back as medical literature extends, they have embraced cases, both of external and of internal affection, where like phenomena arise independently of exterior lesion. The earliest observers of gout, carbuncle, or erysipelas, must have seen exterior parts of the body becoming hot, swollen, red, and painful, though with no ostensible injury, mechanical or chemical, from without; and conclusions which were formed as to external diseases would soon extend themselves to whatever seemed kindred in the symptomatology of internal organs. To us, with present knowledge, these inferences seem obvious. Yet it is not a trifle that the important generalization which is implied in our present use of the word "inflammation" had been made so many centuries ago. Observers had already mastered one very great lesson in pathology. They had learnt to recognize the morbid action irrespectively of its site or cause. They had learnt to see in inflammation a definite state of disease which various causes might produce, and into which any organ might be brought; but which, however caused, or wherever existing, was to be considered as substantially the same.

I. Description of the Inflammatory Process and of its Symptoms and Causes.

A. THE PROCESS.[1]

The author who engages to give information to others on any subject with which he is supposed to be conversant, takes upon himself a serious responsibility. His first duty is to place his readers in complete possession of all the facts relating to the subject, which have been accepted by scientific men up to the time at which he writes, including in his statement such collateral information as is necessary for correctly judging of the grounds of their acceptance. But in addition to this primary obligation the reader has a right to expect that he will not be presented with a mere narrative of unconnected observations which he must himself arrange and apply to the solution of the questions at issue, but that the work of comparison and analysis shall be done for him, and those conclusions stated in clear language which have the best claim to be incorporated in the ever-changing body of scientific doctrine.

In the preparation of the following essay on the process of inflammation, I have made it my object to fulfil both these obligations without going beyond them, deeming that by doing so I should be most likely to make my performance of practical use. I have striven, above all, to be cautious in the selection and statement of facts, remembering how often misstatements, which find their way into the writings of those who assume to teach, are apt to retain their place long after the sources whence they were derived have been forgotten.

I have myself repeated most of the observations and experiments to which I have referred. I have done so, however, not so much in the hope of adding to them or correcting them, as for the purpose of making myself conversant with the methods and results.

It is hard to have to acknowledge that during the last ten years no research of any importance relating to the questions which will occupy us in the following pages has appeared in this country. The fact that we have to submit to receive instruction at the hands of German pathologists, instead of meeting them on equal terms, unwelcome as it is, is very easy to account for. In the present position of pathology, the methods which in times past have been employed with such signal success in this country are exhausted. Although it would be a great mistake to say that all that can be learnt by the rough investigations which can be made in the *post-mortem* theatre is already known, yet it cannot be doubted that for some years past every important advance in the science of disease has been accomplished, not by the collection of isolated observations, but by the same methods of systematic experimental research which are employed in physics and chemistry. The Pathological Institutes of Vienna

dung) and generally to the languages having nearest affinity with German, as much as to the Greek and its derivatives. And the following memorandum, for which the writer is indebted to the kindness and learning of Mr. Charles Rieu of the British Museum, shows the same thought to have been at work in other languages: "I find that the Arabic equivalents of 'inflammation' in its medical sense are التهاب *iltihâb* (literally a blazing-up), and also حرارة *harárah* and سخنة *sakhanah*, which both mean *heat*. In Sanscrit I find दाह *dáha* (burning), ज्वाला *jwálá* (flame), ताप *tápa* (heat), with its compounds *upatápa* and *santapa* (internal or general heat). My learned friend Mr. Zedner tells me that the best Hebrew equivalent is קדחת *kadakhat* (kindling, burning), which is especially applied to the burning of the fever."

[1] [This essay, by Dr. Sanderson, has been transferred from Vol. V. of the last English edition.]

and Berlin have no counterparts in Great Britain. The want of them is not only disadvantageous, but fatal to progress—partly because they are necessary for the effectual carrying out of experimental inquiries, partly because, without them, that education in the methods of exact research by which alone a real pathologist can be produced is impossible.

Introduction.—By the "process of inflammation," I understand the succession of changes which occurs in a living tissue when it is injured, provided that the injury is not of such degree as at once to destroy its structure and vitality. With reference to their origin, all inflammations may be comprised in two classes—extrinsic and intrinsic. Of these two terms, the former is applicable to all those cases in which an injury, either sustained by the affected part or inflicted elsewhere, is the obvious cause of the morbid process; the latter to those inflammations which, from the concealment of their cause, are commonly called idiopathic. If, however, we desire to speak accurately, we must discard this word altogether; for there is no case in which it can be reasonably doubted that an injury must have preceded the earliest sign of local disorder, however little we may know either of the nature of the agent or of the mode of its action. We might advantageously substitute for idiopathic either of the words intrinsic or secondary; but inasmuch as there is no channel by which an agent from within, *i. e.*, from some other part of the body, could penetrate into a tissue, excepting by the bloodvessels or lymphatics, we are entitled to use the only word which fully expresses this view of the mode of introduction of the material cause, and to designate all so-called idiopathic inflammations *infective*.

From what has been said it may be readily understood that the primary inflammations naturally affect those parts principally which are exposed to external influences, while those of the other class occur by preference in parts and organs to which there is no access excepting through the circulation. These distinctions, however, are not constant, for there are many instances in which secondary inflammations affect external parts, and many others in which internal organs are the seat of primary inflammations, as, for example, when nephritis arises from exposure to cold. Much more important distinctions, however, may be based on a comparison of the structural changes which the two processes determine in the tissues affected; or, in other words, on their pathological anatomy. In making this comparison, there is one important principle to be borne in mind. *In all inflammations, the form of the lesion is dependent on that of the area of influence of the injury.* Thus, in those cases of primary inflammation in which it may be supposed that an impression received by afferent nerves distributed to mucous or cutaneous surfaces, is reflected to internal organs (as in the case of nephritis from cold, already referred to), the area of influence of the injury is wide enough to comprise whole organs, and the resulting lesions are of corresponding extent. In the strictly local inflammations, the correspondence in form between cause and effect is, of course, closer and more obvious, the area of a traumatic inflammation being larger than that of the injury which produces it, but of exactly similar form. As regards infective inflammations, the correspondence is not so plain, but the consideration of their pathological anatomy is sufficient to satisfy us that it is equally complete. It is the anatomical character of all infective inflammations that the lesions to which they give rise are disseminated rather than diffused. Particles of matter, of the nature of which we can assert nothing, excepting that they are of extreme minuteness, are conveyed from a primarily inflamed part to other parts previously healthy, and become foci of infective induration or suppuration (miliary tubercles, pyæmic abscesses) each of which is the product—if one may be allowed the expression—of a single seed.

Although in a treatise on inflammation all the forms of the process ought to be discussed, I have thought myself justified in omitting the whole subject of secondary indurations and suppurations on the present occasion; not that I underrate its importance, but that the material for its satisfactory discussion is still wanting. The intimate pathology of the process of infective inflammation (*e. g.*, tuberculous, scrofulous, or pyæmic) has been only very recently subjected to experimental investigation, so that, although pathologists are beginning to see the bearing of the facts already observed on clinical experience, the subject is not yet ripe for dogmatic exposition.

For a similar reason the consideration of those cases in which inflammatory processes originate at a distance from the locality directly affected by the injurious agent, must also be omitted; for the ideas we at present entertain with respect to them are not founded on experiment, but merely inferred by analogy, *i. e.*, by comparison of what occurs with other known processes. The actual limits of pathological knowledge seem therefore to confine the scope of the present article to the discussion of those purely local inflamma-

tions which arise in a tissue in consequence of the direct application of injurious stimulation.

The purpose of this article is therefore to describe the effects of injurious irritation of tissues. Enumerated in the order of their apparent occurrence, they are (1) disorder of the circulation, (2) transudation of the constituents of the blood, and (3) altered mode of growth of the elements of the inflamed texture. As, however, it is more convenient to divide the consideration of these several derangements of function according to their seat than according to their nature, I propose to describe them under two headings—the first comprising all those changes which have their seat in the bloodvessels; the second, the alterations of the tissues.

Section I.—Changes which have their seat in the Bloodvessels.

I. Disorder of the Circulation.

When a grain of dust is accidentally introduced underneath the upper eyelid, much pain is felt, and the conjunctiva becomes vascular. This effect occurs so rapidly that it is difficult to suppose that the obvious dilatation of the vessels has been preceded by a preliminary state of contraction. On the other hand, we know from direct observation and measurement that if we irritate a minute artery, it contracts at the point of irritation. How are these two apparently opposed facts to be reconciled? Are we to suppose that, notwithstanding the shortness of the time that intervenes between the application of the stimulus and its effect, the apparent paralysis has been preceded by a transitory contraction, or are we to believe that the condition of the arteries which leads to the increased activity of the capillary circulation is intermediate between that of complete relaxation and that of spasm?

Before entering on the consideration of this question, it will be well to give a short account of the vascular changes as they are seen in actual progress in the transparent parts of certain of the lower animals. For years the web of the frog's foot was the only field of observation. Now that, by the use of curare, we are enabled to obviate the difficulties arising from muscular movements, preference is often given to the tongue or the still more transparent mesentery.

When the mesentery is spread out (in the way to be hereafter more particularly described) for microscopical examination, the first change which is observed in the circulation, as a result of exposure to air, consists in dilatation of the arteries; the increase of width being accompanied by a corresponding increase of length, which manifests itself in more or less contortion. The dilatation begins immediately, and is ushered in by no antecedent stage of contraction. It is, however, progressive; the diameter of the artery gradually increases for ten or twelve hours, at the end of which period it is often twice as great as it was before; having thus attained its maximum, its size remains unaltered for many hours. This dilatation of the arteries is followed by a similar change in the veins, but inasmuch as there is a considerable interval between the two events, a time occurs at which the arteries, instead of being sensibly smaller than the veins which correspond to them, far exceed them in diameter.

Along with these changes the rate of movement of the blood is also altered. At the beginning of the process the circulation is quicker than natural. Yet, although the two changes go on at the same time, the acceleration cannot be regarded as a result of the increase of calibre; for the inevitable consequence of dilatation would be diminution, not increase, of the rate of movement, supposing the activity of the heart and the resistance opposed by the capillaries of distribution to remain the same. The absence of any causal relation between the two is still more clearly shown by what is observed at a later period; for whereas on the one hand, as has already been stated, the dilatation lasts for many hours, the acceleration is confined to the first stage of the process. The rate of movement soon returns to the normal, and this is shortly followed by a change in the opposite direction; so that by the time the arteries are fully dilated the circulation is much slower than it was originally.

Such are the main facts as they occur in the frog's mesentery. In so far as every inflammation begins with increased activity of the capillary circulation of the affected part, which is followed by diminished circulation, they may be considered as representative. Nothing, however, can be learnt from them as to the relation between these changes and the variations which occur along with them in the degree of contraction of the vessels themselves. For the study of this relation we must have recourse to other tissues in which the conditions of vascular contraction are better understood than they are in the mesentery. But before doing so it appears necessary to give a short account of what is at present known as to the influence of the nervous system on the bloodvessels.

During the last ten years important additions have been made to our knowledge of the innervation of the arteries. Many new facts have been discovered, and others previously known are better under-

stood. To attempt fully to discuss them would exceed the scope of this article. I shall, therefore, confine myself strictly to those physiological considerations which have an immediate bearing on the disorder of the circulation which manifests itself in inflammation. Until Bernard proved by experiment that the nerves which preside over the arteries of the integument of the head are contained in the cervical portion of the sympathetic, the very existence of vaso-motor nerves was merely matter of inference. For a long time after that discovery, physiologists had no precise knowledge of the vascular nerves of the rest of the body. More recently, the mode of innervation of many other parts and organs has been demonstrated experimentally, particularly the right of the splanchnics to be regarded as the vascular nerves of the abdominal viscera, and the derivation of the vascular fibres of the upper and lower extremity from the sympathetic system, by means of communicating branches passing between that system and the anterior roots of the spinal nerves. By these researches the doctrine which has long been considered probable, viz., that all vascular nerves pass through the ganglionic nervous system, has been established. At the same time, it has been shown that although the vascular nerves are immediately derived from the sympathetic, their ultimate origin is to be found in the cerebro-spinal nervous system, as evidenced by the fact that when any part of the ganglionic cord is isolated by the division of its spinal attachments its vaso-motor functions are paralyzed, the same vascular effects being produced as if the sympathetic were itself destroyed. We further learn that the vaso-motor nerves are not only subject, like other efferent nerves, to the direct action of stimuli, but that they may be excited in the reflex way by stimulation of certain afferent spinal nerves. And hence we are compelled to admit that the whole vaso-motor system is under the control of an excito-motory centre. The precise position of this centre is as yet uncertain. We know, however, that it is in the intra-cranial part of the cord: in the first place, because some of the afferent nerves in relation with it are cranial, and secondly because section of the cord immediately below the *medulla oblongata* produces paralysis of the whole vascular system. Of the afferent nerves above referred to, the most important is that which is now known as the depressor,[1] a branch of the vagus, the excitation of which by a feeble interrupted current leads to a general reflex acceleration of the flow of blood through the capillaries.

As in other parts of the nervous system, the special physiology of the vascular nerves is known almost exclusively by experiments, in which the effects produced by the stimulation or division of particular nerves are observed. The most important results of this kind of investigation are, that section of a vascular nerve produces congestion of all the tissues to which it is distributed; that excitation by the interrupted current, or by mechanical means, produces constriction of the minute arteries presided over by the irritated nerve, and consequent anæmia; *that excitation of a sensory nerve produces increased activity of the capillary circulation in the part in which the nerve originates;* and, finally, that all arteries manifest alternating states of contraction and dilatation, their rhythmical movements being entirely independent of those of the heart and of breathing, and ceasing when the vessel is paralyzed by division of its nerves.[1]

Of these results, the one which has the most direct relation to our present inquiry is the third. It is founded, as regards mammalia, on the well-known researches of Ludwig and Lovén, of which I content myself with giving a very cursory account, referring the reader to the original paper for more complete information.

All of Lovén's experiments were made on curarized rabbits[2] in which respiration was maintained artificially, so as to avoid the disturbing influence of muscular movements. The nerves selected for excitation were the large nerves distributed to the external ear of the rabbit, and the *dorsalis pedis*. When the central end of a divided auricular nerve is excited by feeble induced currents, congestion of the corresponding ear follows in a period which varies from three to six seconds. This congestion is more intense than that produced by section of the sympathetic, and

[1] For a full account of this subject, see E. Cyon and C. Ludwig, "Die Reflexe eines der sensiblen Nerven des Herzens auf die motorischen der Blutgefässe." Ludwig's Arbeiten, 1867, p. 77.

[1] Of these results, the first and second may be easily demonstrated in the rabbit by section of the cervical sympathetic followed by excitation of the peripheral end of the divided nerve; in the frog by section and excitation of the spinal cord. The effects of the excitation of the depressor nerve can only be shown in the rabbit. The modes of experiment required are described in my physiological lectures recently published in the Medical Times and Gazette.

[2] I have found, however, that all the facts observed can be demonstrated in animals under the influence of chloral (six grains or more in solution injected into a vein). In this way the experiment is rendered much easier, and can be done without inflicting any pain on the animal.

is accompanied with obvious dilatation of the arteries, varying in duration according to the degree of the excitation, and the time for which it is continued.[1] In the experiments in which the *n. dorsalis pedis* was excited, the *arteria saphena* was made the subject of observation. As this vessel in the rabbit is easily exposed in its long course down the inner surface of the thigh, derives its vaso-motor branches exclusively from the *n. saphenus*, and is distributed in great measure to the same region as the *dorsalis pedis*, it is particularly suited for the purpose. The results are as striking as in the other case. The vessel begins to enlarge and pulsate visibly a few seconds after the commencement of the stimulation. The dilatation soon attains its maximum and begins to subside, lasting only a very short time after the removal of the electrodes from the nerve.[2]

In the frog the vascular nerves which supply the web find their way by various channels to the arteries to which they are distributed, so that there is no single trunk by the division of which these vessels are completely paralyzed. It is probable, indeed, that the distribution of the vascular filaments differs in different individuals, for while in some frogs division of the sciatic nerve in the thigh widens the arteries very distinctly, in others it produces no appreciable effect, either on the state of the vessels or on the activity of the circulation. There is a similar uncertainty in the results produced by exciting the peripheral end of the divided sciatic, which obviously, if that nerve always contained vaso-motor filaments, ought always to induce arterial contractions. In some frogs it is so, *i. e.*, when the peripheral end is excited, the arteries contract markedly, and the circulation is suddenly arrested, but in others the effect is so inconsiderable as scarcely to admit of demonstration. If, however, the central end of the divided sciatic be excited, the opposite effect—namely, increased activity of the circulation—shows itself with much greater constancy, proving that however variable may be the proportion in which vaso-motor filaments are contained in the sciatic nerve, the arteries of the web are always supplied more or less completely through other channels.

The accelerating influence of excitation of the central end of the divided sciatic on the circulation has been lately so carefully studied by Professor Stricker and Dr. Riegel that there can be no doubt of its nature. The method they employ consists in comparing the movement of the blood-corpuscles in a selected arteriole with that of a current of water containing particles of solid matter in suspension, which is so arranged as to pass through a horizontal tube fixed on the eye-piece of the microscope at such a distance from the eye-glass as to be distinctly seen by the observer. The apparatus by which this current is produced is so constructed that its rate can be varied at will, and its actual velocity at any given moment can be determined. The comparison is made by first fixing the attention on the arterial current, and then accelerating or retarding the test-current until the two velocities are equal. By this means it is obvious that any diminution or increase in the rate of movement can be appreciated with the greatest exactitude. With a view to the observation, the frog must be slightly curarized ($\frac{1}{200}$ of a grain of curare in solution injected under the skin). The sciatic nerve having been divided on one side, the web is placed under the microscope, so that a small artery passes through the field in a direction which coincides with that of the test-current. As soon as the two movements have been brought to agreement, the central end of the sciatic is excited by a moderate current, immediately after which the acceleration begins, and goes on increasing so long as the irritation is continued, even when the observation lasts for half an hour, or longer.[1] In all Dr. Riegel's experiments the acceleration of the blood-stream was associated with some narrowing of the vessels. This observation was so carefully and so frequently made by him, that I should not doubt of its reality, even if I had not satisfied myself of its truth by repeating it. Its importance is obvious, for it affords the strongest ground for believing that in certain states of the arteries accelerated flow of blood may be associated with persistent reflex arterial contraction.

There are several instances known to physiologists in which contractions of arteries are produced which are not attended with increased activity of capillary circulation, but, on the contrary, with anæmia—as, for example, by excitation of the peripheral end of the sympathetic in the neck after division, in the rabbit, or by excitation of the spinal cord in the frog. If this were only the case when vaso-motor nerves are irritated directly, we could more readily understand it; but it also happens under conditions which so closely resemble those which we have been con-

[1] In my experiments, the dilatation had often disappeared ten or twelve seconds after the commencement of excitation.

[2] Chr. Lovén, "Ueber die Erweiterung von Arterien in Folge einer Nervenerregung." Ludwig's Arbeiten, 1867, p. 1.

[1] Riegel, "Ueber die reflectorische Innervation der Blutgefässe." Med. Jahrbücher, 1871, p. 101.

sidering, that at first sight the results are difficult to reconcile. Saviotti has lately found that by exciting the cutaneous surface in various ways, *e. g.*, by tapping on the integument of the belly, by pricking the skin of the same part or of the back, or by pinching the toes, very marked contraction of the arteries of the web of the frog's foot can be produced, which is attended not with increased but diminished progressive movement of the blood, amounting for the moment to complete arrest of the circulation. As I have said, this looks at first contradictory, but before we judge of its bearing on our present question we must call to mind that the conditions of Saviotti's and Riegel's experiments are not so comparable as they seem. It is well known as regards some at least of the modes of irritation employed by Saviotti, that they act not merely on the vaso-motor nerves but on the vagus heart-nerves. I need not remind the reader that tapping on the belly of the frog arrests the movements of the heart in diastole just in the same way as direct excitation of the vagus itself does. Consequently in Saviotti's experiment we are not merely obliged to admit the possibility that the arrest of movement is partly cardiac, but are tolerably certain that it must be so. This consideration is of great importance ; for although there is no doubt that anæmic contraction of arteries is an ordinary consequence of direct stimulation of vaso-motor nerves, there is no case (except that of Saviotti's experiments) in which anæmia is produced by reflex irritation.[1]

Our knowledge of the innervation of the bloodvessels is, notwithstanding the progress which has been made during the last few years, too imperfect to enable us to harmonize all the facts. But the impossibility of constructing a complete theory on the subject does not prevent us from drawing some inferences which will be of use in enabling us to understand what happens in inflammation, at all events better than we should do without them. From what has been stated, it is tolerably clear that whatever difference there may be in other respects, there is one effect of exciting the sensory nerves distributed to any part which is pretty constant, viz., increased activity of the circulation; so that whether the actual quantity of blood existing in the part at any given moment be greater or less, the quantity of blood which passes through it in a given time is certainly greater.

In the commencement of the process of inflammation in the web of the frog's foot the successive changes are similar to those I have already described in the mesentery, but differ considerably according to the irritant employed. Most irritants, such as weak solution of caustic soda, dilute sulphuric acid, etc., produce dilatation first of the arteries and subsequently of the capillaries, with marked acceleration of the circulation—these conditions being followed by arterial contraction and capillary anæmia. But liquor ammoniæ and carbonate of ammonia in substance, appear always to occasion a certain degree of primary arterial contraction, which begins in one or two minutes after excitation, and is attended with retarded flow of blood through the capillaries, with distension of the branches given off by the artery nearer the heart, and increased activity of circulation in the neighborhood of the irritated part. This state of things lasts for an hour or two, and is succeeded by dilatation and acceleration. In other words, ammonia and carbonate of ammonia produce results which are directly opposed to those of other stimuli. Croton oil appears to occupy an intermediate position between the first-named stimulants and ammonia, for while it always gives rise to acceleration of the flow of blood as a primary result, this change is sometimes associated with widening, sometimes with narrowing of the arteries. So that here, as in the case of reflex electrical stimulation of sensory nerves, the only fact which is constant is acceleration.

In order to judge whether the two kinds of acceleration we have been considering are of the same or opposite nature, the best way is to observe their action simultaneously in the same part. If, for example, in the web of the frog's foot the acceleration due to excitation of the central end of the sciatic is of the same nature as that of inflammation, we should expect it to be increased by local irritation ; and, conversely, the effect of irritation, if already existing, to be heightened by exciting the nerve. The very careful experiments of Dr. Riegel show that it is so. Having found that after section of the sciatic the effects of irritation were slightly retarded, but otherwise unmodified, he repeated the observation in another animal, excited the central end, and then applied croton oil to both webs. On the injured side the accelerating effect of the croton oil lasted much longer than on the other, so that at the time stasis had already set in on the sound side, the circulation was going on more briskly than natural on the injured side.

As regards the precise nature of the modification of vascular contractility which is associated with the primary quickening of the capillary circulation,

[1] Saviotti, "Untersuchungen über die Veränderungen der Blutgefässe bei der Entzündung." Virchow's Archiv, vol. i. p. 592.

we cannot venture to speak in any terms more precise than have been already employed. The effect of local irritation is certainly not to paralyze the arteries leading to the irritated part, but rather to modify their *tonus* in such a way as to facilitate the flow of blood through them. For the present we must be content to leave the question open, for no good would be gained by endeavoring to conceal the insufficiency of our knowledge under a comprehensive theory.[1]

In all forms of inflammation of sufficient intensity, the circulation after a variable period of excitation becomes retarded. The effect is so closely associated with the other phenomena of the second stage of the process of inflammation, that it cannot be advantageously studied until they have been considered (see p. 44).

II. EXUDATION OF LIQUOR SANGUINIS AND LEUCOCYTES.

It is now many years since it was taught by Dr. C. J. B. Williams, as the result of his own observations on the phenomena of inflammation in the web of the frog's foot, that in the second stage of the process, when the capillary circulation is becoming retarded, there is an apparent increase in the number of white blood-corpuscles in the vessels, and that they manifest a remarkable "disposition to adhere to their walls."[1] Dr. Williams attributed these appearances to the production in the vessels of inflamed parts, of young colorless blood-corpuscles differing from those ordinarily met with in their consisting, not of cells (in the sense in which the word was then, and for many years afterwards understood, as implying the existence of nucleus, membrane and contents), but of masses of gelatinous consistence. He considered that their tendency to adhere to the internal surfaces of inflamed vessels, and to creep along them, was due to their not having membranes. He further observed that "in the frog's web, after inflammation has continued for some hours, there appear outside of the vessels, especially where the strongest current encounters the most complete obstruction, white globules or corpuscles with specks in them, exactly like the pale granular globules within the vessels." He did not, however, suppose that the objects so exactly resembling each other which he saw outside and inside of the membrane respectively, were in reality identical; for although Dr. Addison had already maintained that pus globules and the white globules of the blood were indistinguishable from each other, and had represented that in inflammation the white globules first passed into the substance of the wall of the bloodvessel, and were then thrown out from it, it appeared to Dr. Williams so difficult to understand their passage through the walls of vessels in which no pores are visible under the highest magnifying powers, that such an explanation could not be accepted.

In 1846 the statements of Dr. Addison were confirmed by the late Dr. Augustus Waller. His paper on the subject displays such clearness in the description of the phenomena he observed, as to leave no doubt in the mind of the reader that he actually saw what he represents. "In some instances," says Dr. Waller, "the manner in which the corpuscle escaped from the interior of the tube could be distinctly followed; that part of the tube in contact with the external side of the corpuscle gradually disappeared, and at nearly the same time might be seen the formation of a distinct line of demarcation between the inner segment of the corpus-

[1] Many physiologists are of opinion that the arteries do not act merely as dead elastic tubes, but are endowed with powers of contraction analogous to those of the intestine. If this be admitted, it can be easily shown that the quantity of blood conveyed by an artery in a given time, and consequently the activity of the capillary circulation, might be increased by alterations in the contractility of the tube of a nature the very opposite of that of relaxation. Such a theory supposes that an artery, after it is distended by the injection of blood from the heart, does not content itself with returning to its state of elastic equilibrium, but that at a variable interval after receiving the systolic shock of the heart it contracts actively on its contents, just as a bit of intestine would do, and thus assists in propelling them. Admitting it to take place, the effect of such contraction would depend not merely on its intensity, but on the relative duration of the period of arterial distension as compared with that of the succeeding collapse. Thus if the contraction were so immediate as to happen while the artery was still acted upon by the heart, and consequently to coincide with what would otherwise be the period of greatest distension if the artery were a dead elastic tube (that is to say, about a tenth of a second or so after the shock), it is evident that it would tend to impede the circulation by increasing the resistance of the artery; but if, on the other hand, it were postponed until after the operation of the *vis a tergo* had ceased, it would not only keep up the flow of blood during what would otherwise be the period of greatest retardation, but would prepare the way for a more effectual filling of the artery at the next systole by previously emptying it of its contents.

[1] Principles of Medicine, 3d ed., p. 330.

cle and the fluid parts of the blood in contact with it. Any slight agitation then was capable of disengaging the corpuscle from the vessel to which it was now external," etc.[1] This passage is taken from a description of one of Dr. Waller's experiments. I quote another which contains his explanation of the phenomena. "In endeavoring to account for the fact of the passage of the corpuscles through the vessels, we find considerable difficulties. It cannot be referred to the influence of vitality, as it is observed likewise to take place after death. It may be surmised, either that the corpuscle, after remaining a certain time in contact with the vessel, gives off by exudation from within itself some substance possessing a solvent power over the vessel, or that the solution of the vessel takes place in virtue of some of those molecular actions which arise from the contact of two bodies; actions which are known as exerting such extensive influence in digestion, and are referred to what is termed the catalytic power." That the speculations and observations of Dr. Addison, even when so definitely confirmed by Dr. Waller's experiments, fell into oblivion, is to be attributed partly to the theories about cells which then prevailed, and partly to the extreme difficulty of the investigation. For it is to be remembered, to Dr. Waller's great credit, that neither curare nor chloroform, which have since so wonderfully facilitated research, were at his disposal, and that consequently anything like minute observation of the phenomena was rendered almost impossible; for it was only by patiently waiting for short moments of tranquillity that the observer could see anything.

Before proceeding to the consideration of the discoveries which have rendered Professor Cohnheim's name so well known, it is desirable to give some account of the successive steps of investigation by which the true relation between the colorless corpuscles of the blood and other similar forms occurring in the tissues, either in health or disease, has been recognized. The common physiological property by which all these bodies are associated is that of spontaneous movement, manifesting itself either in progression or merely in continuous change of form. The bodies possessing this property are called in German by the terms *bewegliche Körperchen*, *Wanderzelle*, *Lymphkörperchen*, for which I propose to employ the English equivalent leucocyte,[1] understanding it to mean a mass of contractile living protoplasm. The importance of this definition in relation to our present inquiry is very great, for so long as a blood-leucocyte was supposed to be a cell, in the sense in which the term cell was used twenty years ago, it was quite impossible to understand how it could find its way through a structureless membrane; but from the moment that it was understood to be a mass of contractile material similar in all respects (which can be judged of by observation) to that which forms the body of an amœba, and endowed with a similar faculty of movement, the process became much more intelligible. Although the comparison between the movements of amœbæ and those of leucocytes is so familiar, it cannot be considered either an undue digression from the subject, or a waste of the reader's time, to recall to his recollection some of the facts relating to the mode of life of these organisms which fit them to serve as illustrations of the contractile corpuscles of the higher animals.

With this view the best examples which can be selected are the gigantic amœbæ, which are known to biologists as the Plasmodia of the Myxomycetes, and the more familiar forms which are closely related to the Monads. The myxomycetes, although possessing some of the characteristics of animals, have been always, on account of their development and mode of growth, associated with the fungi.[2] Like other fungi, they originate from spores. If the spores of *Physarum* (a genus of myxomycetes) are sown in water on an object-glass, and examined under the microscope twenty-four to thirty-six hours afterwards, the water is seen to be peopled with contractile corpuscles, each of which is at first provided with a single

[1] "Microscopical Observations on the Perforation of the Capillaries by the Corpuscles of the Blood, and on the Origin of Mucus and Pus Globules." By Augustus Waller, M.D. Philosophical Magazine, vol. xxix. p. 397, 1846.

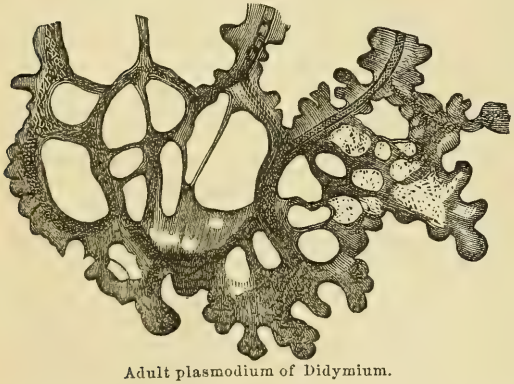
[1] Dr. Williams, in a recent note (Med. Times, Jan. 21, 1871), objects to the term leucocyte, that the body to which it is applied is not a cell, and suggests the adoption of a new word, viz., Sarcophyte, which corresponds more exactly with its anatomical characters and its physiological properties. I have nothing to advance in answer to Dr. Williams's arguments. Sarcophyte is clearly the more expressive and accurate word, but it is unknown; whereas leucocyte is well understood on both sides of the Channel. Moreover, the word cell, and its Greek equivalent, have so entirely lost their original meaning, that surely no misunderstanding can arise from their use.

[2] L. Cienkowski, "Das Plasmodium. Zur Entwickelungsgesch. der Myxomyceten." Jahrbücher für wissenschaftliche Botanik, vol. iii. pp. 325, 400.

cilium, and contains, in addition to a contractile vesicle, a delicate vesicular nucleus, usually placed in the neighborhood of the cilium. In its original state the corpuscle moves about so actively that the contractions of its substance cannot be studied; but after a while the cilium falls off or is retracted, and it then assumes in every respect the aspect and character of an amœba. Let us for a moment study its motions.

The mass is constantly changing its form. But as these changes go on in all parts of the hyaline substance of which it consists, simultaneously, the only way in which they can be understood is by confining the attention to one point at a time. If this is done it is seen that each act of movement begins by the budding out of a ray or process of contractile substance in a centrifugal direction. What next happens varies in different cases. Sometimes the projection subsides just in the same way as it was formed; at others the finely granular fluid or rather labile matter, which occupies the more central parts of the corpuscle, streams into the offshoot, gradually widening it out, until it grows into a mass greater than the remainder, which it finally draws into itself. It is evident that the process last described must always be attended with locomotion, for each time it is repeated the whole mass rallies round a new centre, the position of which corresponds to the extremity of the offshoot. If the amœba always sprouted in the same direction, the progress would be continuous and rectilinear; as, however, there is no appreciable order in its efforts, its locomotion is correspondingly irregular.

Fig. 1.



Adult plasmodium of Didymium.

The form of the adult plasmodium of Didymium, another genus, is shown in Fig. 1. It consists of a reticular film of gray fibres which spreads over the rotten leaves on which the plant vegetates, and would be regarded by the casual observer (if he recognized its claim to be considered a living structure at all) as undoubtedly a fungus. Under the microscope it is found to be neither more nor less than an enormous mass of contractile protoplasm; for every part of it is constantly undergoing changes of form similar to those already described in the minute amœba, with which (as Cienkowski's researches have clearly shown) it is organically continuous. As illustrative of the manner in which hyaline contractile material may shape itself into specific form without the intervention of cells, it is well worthy of our attention. Its mode of growth can be best understood by observing what takes place at the edge of the network. Here it is seen that the filaments grow terminally, and that although there is amœboid movement in every part this movement is much more active at the growing points than elsewhere. It is further seen that the process by which the growing end lengthens, is exactly similar to that by which the original amœba throws out rays. In each filament the outer part appears to be hyaline and contractile, the central part labile and granular; and when the process of elongation is carefully observed, it is seen to consist first of a budding out of the external substance, and secondly of an afflux (preceded by more or less marked alternations of ebb and flow) of the axial semi-fluid matter towards the growing point. The reticular arrangement of the filaments results from the fact that every marginal growing end meets with another, with which it unites so as to form a loop. The union, however, is not instantaneous, but gradual. For a time the two ends are merely in contact, the labile axial matter being separated by a double septum of hyaline substance. Gradually the septum melts away, and a channel of communication is established in which the ebb and flow of currents can be distinguished.

The purpose I have had in view in giving this short sketch of the mode of life of the myxomycetes is to show that in contractile protoplasm the two functions of motion and growth are, so to speak, confused together in such a manner that the more closely we scrutinize the mode in which they are exercised the more difficult does it appear to distinguish them. No reference has as yet been made to another power which all amœbæ possess—that of absorbing the nutritive substances with which they come into contact. This property is manifested in perfection in the colossal amœbæ we have been studying, which not only appropriate material de-

rived from the soil with which they are in contact by their external surfaces, but surround their food with their own substance for the purpose of digestion (Fig. 2). I prefer, however, to seek for an illus-

Fig. 2.

Fig. 3.

Fig. 2. A plasmodium beginning to surround a vegetable cell containing chlorophyll.

Fig. 3. At the lower part of the figure a Vampyrella is beginning to adhere to a cell containing protoplasm and chlorophyll granules, which it is about to plunder. The other two cells have been perforated and their contents drawn into the bodies of the Vampyrellæ, which have retracted their processes.

tration in the history of those more minute forms which, from their close relation to the Monads, have always been regarded as animal.

I select as an example an amœba called by Cienkowski *Vampyrella Spyrogyræ*,[1] the specific name of which is derived from the confervoid alga on which it lives parasitically. Its appearance is shown in Fig. 3. It is granular towards the centre, hyaline at the surface, and the superficial part shoots out into pointed rays, or less frequently buds into obtuse promontories, in which an oscillation of granular matter is seen similar to that already described. It moves about apparently without purpose until it meets with a filament of spyrogyra. It then adheres to the external cellulose membrane of the alga, and soon penetrates it. It thus comes into contact with the protoplasmic lining (primordial utricle) of one of the cells of which the filament is composed, which it at once proceeds to exhaust of its chlorophyll, drawing it into itself through the narrow opening which it has made in the cell wall. After having plundered several cells in this way, the amœba, much increased in size, entirely ceases its movements, and becomes inclosed in a distinct envelope, in the interior of which new amœbæ are formed by an endogenous process which it is unnecessary to describe.

Although the morphological relations of amœbæ are so various and in many instances so undetermined that no single example can be taken as typical, yet those above related may serve to render more intelligible the following general statement. It appears to be well ascertained that it is the destiny of every amœba, after it has enjoyed its active life for a certain time, to assume the immobile condition, in which it becomes invested in a membrane; and that as this transformation is always preparatory to its entering on the reproductive function, no amœba can itself be a parent. It is also certain that all amœbæ, so long as they continue in the active state, are endowed with a remarkable power of dissolving and absorbing the nutritive substances on which they live. In connection with this faculty, the exercise of which may be regarded as the final cause of all their movements, they are able, at one time, to surround the material to be digested with the substance of their own bodies, at another to penetrate membranes in which there are no visible pores, when such membranes are interposed between them and their food.

Amœboid movements of leucocytes.—The first precise observations on the amœboid movements of leucocytes were those of Professor v. Recklinghausen, contained in a paper on suppuration which appeared in Virchow's Archiv in 1863.

The publication of this research may be well considered as the commencement of a new era in histology,[1] not so much on account of the importance of the facts announced in it, as because the author enforced a principle which, at all events in its application to pathology, was at that time new, though it is now recognized by every one—namely that the elements of tissues, especially those in which

[1] Cienkowski, "Beiträge zur Kenntniss der Monaden." Schultze's Archiv, vol. i. p. 203.

[1] It is somewhat difficult to state to whom the merit of having discovered the amœboid movements of leucocytes is to be assigned. There is no doubt that they had been noticed by several anatomists before they were made the subject of special investigation. Among the more important early observations on the subject may be noticed those of Virchow on the corpuscles of hydrocele fluid (Virchow's Archiv, vol. xxviii. p. 238), of Lieberkühn on the fluid of ascites (Müller's Archiv, 1854, p. 15), and those of Messrs. Busk and Huxley on mucous corpuscles, in a note to their translation of Kölliker's Microscopical Anatomy (p. 46).

life is most active, are so altered in the very act of dying, that the appearances they exhibit when dead, and still more when disfigured by immersion in such liquids as acetic acid or water, are mere caricatures of their true aspects; for although the dead remains may be full of instruction, yet if we wish to know organic forms as they are, they must be studied either in the living state or at all events under physical and chemical conditions resembling those of life as closely as possible.

Guided by this principle of research, Recklinghausen was able to show, for the first time, that the changes of form of leucocytes are of the same nature as those of amœbæ, that they are capable of surrounding particles of any kind, if sufficiently small, with their own substance, and that they possess the power of moving from place to place. The first of these facts is established in his paper by observations on the pus corpuscles which are to be found in the liquid obtained by puncturing the anterior chamber of the eye of the frog a few days after keratitis has been produced by the application of nitrate of silver to the cornea. The description given of the movements as they are seen in the turbid humor aqueus, provided that it has undergone no change either by evaporation or pressure, is as follows: "The corpuscles differ very strikingly in their form from those from

Fig. 4.

Amœboid leucocytes (after v. Recklinghausen).

which the ordinary descriptions are taken. . . . No globular forms present themselves—only jagged ones, and the prongs vary both in length and number. But what strikes one even after very brief examination is, that each corpuscle is constantly changing its shape. While one prong withdraws itself into the body of the corpuscle, another juts out. Each prong is at first a delicate, homogeneous, somewhat shiny thread, but soon it thickens at the base, lengthening at the same time; then gradually the substance of the corpuscle tends more and more towards it, becoming smaller as the process gets larger, the whole thus assuming an oblong or protracted form. During this transformation . . . the tip of the process is rounded off and subsides into the contour of the corpuscle; or new delicate thread-like processes shoot out, which again undergo the same changes."[1]

The ingestive power of leucocytes is proved by experiments in which Recklinghausen introduced milk into the lymph cavities of frogs, the result being that the blood leucocytes became "choked with milk globules." Subsequently he injected finely divided vermilion with like effect, and in this way introduced a method of research which has since been much employed by pathologists—that of distinguishing the blood leucocytes from those indigenous to the tissues, by feeding the former with some insoluble coloring matter injected into the circulation.

The proof of the faculty of locomotion is derived from another experiment which is in fact only a continuation of that already mentioned. Vermilion having been previously injected into a lymph cavity of a living frog, a rabbit's or dog's cornea taken from an animal several hours dead, is introduced into it, and left there two or three days. The lymph sac of course becomes inflamed, and it is found on removing the fragment that whereas the centre remains transparent, the more superficial parts are turbid. And if the preparation is immediately submitted to microscopical observation under conditions consistent with the maintenance of life (*i. e.*, immersed in a nutritive liquid), it is found that the turbidity is due to the presence of amœboid leucocytes in the cavities of the dead tissue. That these elements are derived from the purulent liquid in which the fragment is bathed, and must therefore have found their way into the positions which they occupy by migration, is evidenced not only by their vital movements and their containing vermilion granules, but by their exhibiting the size and other characters of leucocytes of the frog.[2]

[1] V. Recklinghausen, "Ueber Eiter- und Bindegewebskörperchen." Virchow's Archiv, vol. xxviii. p. 157.

[2] This experiment has been since repeated in a variety of ways. The most striking is that of Prof. Lortet, of Lyons, who found that when any porous substance is introduced into a suppurating cavity, the leucocytes penetrate into it in the same way as they do into the dead cornea. And if the experiment is so arranged that the porous material incloses a liquid (as *e. g.*, when the swimming bladder of a small fish filled with water or saline solution is inserted into an abscess), the liquid soon becomes peopled with leucocytes. The same thing happens when a similar pouch, shaped out of vegetable parchment, is used. Lortet's experiment, as well as those of v. Recklinghausen, have been repeated in the Physiological Laboratory of University College during the past winter. More full

Even at this early stage in the investigation, v. Recklinghausen recognized the bearing of his discoveries on several difficult questions relating to inflammation; as *e. g.*, in explanation of the tendency of pus to find its way to the surface or into the great cavities of the body, and of the mode in which disseminated foci of suppuration originate; and he also brought them into relation with the notions entertained by earlier pathologists as to the part taken by blood-leucocytes in the formation of new tissues. He even went so far as to attribute the collection or accumulation of leucocytes on the surfaces of inflamed serous membranes to migration; but assumed that they must have originated by "proliferation" in the neighboring connective tissue, and must have followed pre-existing channels in their wanderings. Thus, although it may be said that he did not himself, so to speak, complete his own discoveries, and left it to others to develop them to their necessary consequences, there can be little doubt that he gave a new impulse to pathological research, the effect of which has shown itself in the more brilliant achievements of Cohnheim and Stricker.

The experiment by which Cohnheim first demonstrated the escape of the blood leucocytes in the early stage of inflammation is as follows.[1] A male frog, which has been paralyzed by injecting under the skin about $\frac{1}{200}$ grain of curare an hour before, is secured on a plate of glass of convenient size for the purpose. A vertical incision is then made in the abdominal wall about half an inch in length, extending from the lower edge of the liver downwards. As much of the small intestine is then drawn gently out of the visceral cavity as is necessary in order that the mesentery may be evenly spread on a disk of glass which is fixed in a convenient position for the purpose. If the operation is performed with care and skill, it may be effected without bleeding and without in the slightest degree deranging the circulation.[2]

In order to obtain a general view, it is best to commence the examination with a low power. It is then seen that the arteries are smaller than the veins, the latter exceeding the former in diameter by about a sixth, that the arterial stream is quicker than the venous, that it is accelerated appreciably at each beat of the heart, and that in every artery a space can be distinguished within the outline of the vessel, which is entirely free from corpuscles. The arterial stream is so quick that the forms of the corpuscles cannot be discerned, but in the veins both colored corpuscles and leucocytes can be distinguished, and from the first it is noticeable that while the former are confined to the axial current, the latter show a tendency to loiter along the inner surface of the vessel, like round pebbles in a shallow but rapid stream. So far all is normal, and may remain so for many hours, but in most cases changes occur in consequence of the exposure of the peritoneum, which are the beginning of inflammation.

The first abnormal phenomena observed have been already fully discussed —those of increased activity of the capillary circulation. On dilatation of the arteries of the mesentery follows a corresponding though less marked enlargement of the veins. During this stage the observer who desires to note the subsequent changes, must select for that purpose a vein of about $\frac{1}{300}''$ in diameter, the exact width of which it is desirable to measure either with the micrometer, or by marking its outline as projected on a sheet of paper with the drawing prism. For a couple of hours or more (the time varying in different animals) nothing whatever is to be observed except that although the vein gradually enlarges while the velocity of the venous current shows no abatement, the capillary circulation becomes more and more active; but sooner or later a change occurs which must be watched for with the utmost attention. This consists in a marked and almost sudden diminution of the rate of the current in the vein, in which that in the capillaries necessarily participates: it is the forerunner, and in some sense the cause, of the emigration which we desire to witness.

Simultaneously with the retardation,

information respecting them will be found in the author's lecture on Leucocytes, already referred to.

[1] Cohnheim, "Ueber Entzündung und Eiterung." Virchow's Archiv, vol. xl. p. 27.

[2] The most convenient apparatus for the purpose consists of (1) A glass plate four inches long and two and a half inches broad. (2) A common three-inch object-glass, to one side of which a glass disk four-fifths of an inch in width has been fixed with Canada balsam, in such a position that it projects by a third of its diameter beyond the edge of the object-glass near the middle. Around the adherent part of the disk there is an uncovered space of about one-tenth of an inch in width for the reception of the coil of intestine; and outside of this, an imperfect ring of cork to which the intestine may be pinned with fine needle-ends. The object-glass, with its disk, is fixed to a larger glass plate, at such a height above it that the free edge of the disk presses against the side of the frog's body, immediately below the incision, and is thus conveniently placed for the reception of the mesentery.

the leucocytes, instead of loitering here and there at the edge of the axial current, begin to crowd in numbers against the vascular wall, as was long ago described by Dr. Williams.[1] In this way the vein becomes lined with a continuous pavement of these bodies, which remain almost motionless, notwithstanding that the axial current sweeps by them as continuously as before, though with abated velocity. Now is the moment at which the eye must be fixed on the outer contour of the vessel, from which (to quote Professor Cohnheim's words) here and there minute colorless button-shaped elevations spring, just as if they were produced by budding out of the wall of the vessel itself. The buds increase gradually and slowly in size, until each assumes the form of a hemispherical projection, of width corresponding to that of a leucocyte. Eventually the hemisphere is converted into a pear-shaped body, the stalk end of which is still attached to the surface of the vein, while the round part projects freely. Gradually the little mass of protoplasm removes itself further and further away, and as it does so, begins to shoot out delicate prongs of transparent protoplasm from its surface, in nowise differing in their aspect from the slender thread by which it is still moored to the vessel. Finally, the thread is severed, and the process is complete. The observer has before him an emigrant leucocyte, which in all appreciable respects resembles those which have been already described in the aqueous humor of the inflamed eye.[2]

The experiment I have described, even if the phenomena are not observed with that care which is necessary in order to obtain a satisfactory result, is yet very convincing. For even if one fails from want of patience to watch an individual corpuscle through the successive stages of its escape, there are other obvious facts which are too significant to be misunderstood. The accumulation of innumerable leucocytes around veins which were before entirely free, the absence in these bodies of the faintest indications of any process by which they could be supposed to be developed where they are, the obvious identity of the leucocytes outside with those inside, the pedicles by which at all stages of the process many of the corpuscles hang on to the outer surface of the vessels—all these are facts which make it impossible to admit either that the corpuscles have been formed in the situations which they occupy, or that they have migrated from any other quarter excepting from the blood-stream.

In his observation on the same process in the tongue of the frog,[1] Professor Cohnheim follows the method originally employed by Dr. Waller, excepting of course that the animal is curarized, and that in order to facilitate the observation the mucous membrane is partially removed. The process of migration goes on in the tongue just as in the mesentery; but (to quote once more from Cohnheim) "with such promptitude and certainty, and if the expression may be allowed, with such elegance," that he feels tempted to prefer the former to the latter as an object of experiment.

From these facts Cohnheim concludes "that all such corpuscles as are formed in the first stage of an acute inflammation certainly originate from the vessels," but admits that they do not enable us to arrive at any determination of the question whether or not pus-cells originate in other ways in the later stages.

The bare fact of emigration when first announced took every one by surprise. Notwithstanding, it was very soon accepted by pathologists, partly because their minds were prepared by the previous discoveries of v. Recklinghausen, partly because Cohnheim's statements bore upon them the stamp of straightforwardness and accuracy. Unfortunately many of Cohnheim's adherents have not been content with receiving the fact, but as so often happens in similar cases, have attributed to it a wider significance than

[1] See Dr. Williams's Gulstonian Lectures, published in 1841, in the Medical Gazette.

[2] From the description given above, it might be inferred that the experiment is one of great simplicity, whereas in practice it is attended with very considerable difficulty; so much so, indeed, that most persons who have tried it have found failure more frequent than success. The principal sources of difficulty are, 1st, that the time occupied in the first stage of the process, during which the circulation is going on with unabated velocity, is extremely variable; 2dly, that if, from weariness or inadvertence, the attention of the observer is diverted from the selected vein at the commencement of the process of migration, he is very unlikely to succeed in seeing what he desires to see afterwards; for, inasmuch as leucocytes are escaping simultaneously in various parts of the mesentery, they soon accumulate in such numbers that their mode of exit can no longer be distinguished. Yet, notwithstanding these difficulties, no one who has time and patience enough need fail; great care in manipulation is required, but no extraordinary dexterity.

[1] Cohnheim, "Ueber das Verhalten der fixen Bindegewebskörperchen bei der Entzündung." Virchow's Archiv, vol. xlv. p. 333. From comparative observations made recently, I am led to recommend the tongue as decidedly a better subject for study than the mesentery.

that assigned to it by the discoverer himself. The passage I have quoted above affords evidence that the doctrine commonly spoken of as Cohnheim's — that pus-corpuscles originate entirely and exclusively from the blood, and that the tissues have nothing to do with their production—is in reality not his.[1] He evidently sees as plainly as others that, although in the commencement of every acute inflammation the first generations of pus-corpuscles may be emigrants, there is nothing in the facts which contradicts the previously accepted belief, supported as it is by so overwhelming a mass of evidence, that the later generations are the offspring of the inflamed tissues.

I have now said all that appears necessary on the subject of the migration of leucocytes. It remains to notice in few words the parallel process of exudation of liquor sanguinis. The idea that the escape of liquid from the blood into the inflamed parts is a main characteristic of inflammation is an old one; nor indeed is it very easy to see how it could be overlooked, for the swelling which is one of the four cardinal symptoms could not be otherwise explained. It is, therefore, not worth while to occupy space in stating evidence to show that every inflamed part becomes soaked with a liquid which is derived directly from the circulating blood. Nor is it expedient to refer to the doctrines which prevailed when the microscope was first used as an instrument of pathological research, as to the independent origin of pus-corpuscles and other cellular inflammatory products in exuded blood-plasma, excepting in so far as is necessary in order to explain that when we use the term exudation, we mean simply the *act* by which the liquor sanguinis sweats out of the vessels, not either the exuded liquid or the structural elements which were at one time supposed to be spontaneously generated in it. The important relations of exudation with the other phenomena of inflammation will be fully considered under other headings.

III. STASIS.

Another change occurs in the blood-vessels in inflammation, which, as it is subsequent as well as subordinate to those already mentioned, has not yet been adverted to. We have seen that in the mesentery as well as in the tongue of the frog, the vascular enlargement which is produced by irritation is for a certain time associated with an acceleration of the blood-stream, or at all events with no appreciable diminution of its velocity; but that, at an uncertain moment, the current begins to slacken, while the leucocytes hug the vascular wall and finally find their way out. If the part is arranged for observation in a manner conducive to the maintenance of the circulation, the retarded current may go on for a long time without any material alteration; but eventually it is apt to become slower and slower and more and more oscillating, until it ceases, in which case the condition long known as stasis is brought about. This does not, however, consist merely in arrest of the current, for it is observed that in those vessels in which stasis has occurred, the blood is not merely motionless, but much altered in its aspect. It appears as if it were made up entirely of colored corpuscles without liquor sanguinis, and these are packed together in the choked capillaries in such a manner that their individual forms are scarcely distinguishable. The nature of this change was most carefully investigated by Professor Lister in his well-known paper "On the Early Stages of Inflammation."[1] The principal results of his inquiries are as follows: He believes that the accumulation of the corpuscles is due to a property they themselves possess of cohering together; and that they attach themselves to each other in the inflamed vessels in exactly the same way that they cohere in rolls in ordinary blood after its removal from the body. He does not, however, suppose that this cohesiveness of the corpuscles is greater in the blood of inflamed parts than in other blood;[2] for he finds in the first place that vessels leading to or from areas of stasis manifest no tendency to cohesion on the part of the corpuscles; and, secondly, that blood taken from inflamed parts differs in no respect from healthy blood, as regards the mode in which its corpuscles arrange themselves on the object-glass. These facts seem plainly to indicate that the cause of the phenomena is to be looked for, not in the condition of the blood, but in that of the vessels—in other words, that the corpuscles draw to each other, not because they are themselves in an abnormal state, but because the living tissue by which they are surrounded is altered.

[1] I am aware that Prof. Cohnheim has since expressed himself much more positively than in the passage referred to. It is therefore the more important to show what impression was left upon his mind by the facts at the time he observed them.

[1] Philosophical Transactions, 1858, p. 645.

[2] Loc. cit., p. 669. "The adhesiveness which the red corpuscles acquire in inflammatory congestion, though varying in proportion to the degree of irritation, is never greater than occurs in the blood of a healthy part when withdrawn from the body."

This conclusion is rendered even more certain by the recent experiments of Dr. A. Ryneck in the Physiological Laboratory at Gratz. He has shown that all the phenomena of stasis can be produced by irritation in the webs of frogs, in which milk or defibrinated blood of mammalia has been substituted for the circulating fluid. To demonstrate this, fresh milk must be injected under a pressure of from two to three inches by a canula into the *bulbus aortæ* of a curarized frog, the *sinus venosus* having been previously opened. The milk having passed through the systemic circulation finds its way out at the venous opening, completely displacing the natural contents of the vessels. If, then, the web is touched with a rod moistened with ammonia, the phenomena of stasis occur in the irritated part; the capillaries become crowded with milk-globules, exhibiting the appearance of gray cords. When defibrinated blood is used, the results are even more striking, for in this case the choked vessels soon exhibit in every respect the same appearances as in ordinary inflammation.

These results seem to make it perfectly clear that the local changes which lead to the production of stasis must have their seat either in the walls of the vessels, or in the tissues which immediately surround them. To determine this more precisely, Dr. Ryneck varied this experiment by first filling the vessels with an indifferent liquid, such as solution of common salt of proper strength, so as to remove the blood; then subjecting their internal surfaces for a few moments to an agent which, by virtue of its chemical action, might be expected to modify or destroy its vitality; and finally, after replacing the injurious liquid by milk or defibrinated blood, observing the effects of local irritation. Solution of chromic acid, chloride of gold, and sulphate of copper, were found to be well adapted for thus acting on the vessels. The results were decisive. No stasis was produced by irritation in webs which had been thus treated.[1]

IV. STRUCTURAL CHANGES IN THE CAPILLARIES.

Until a few years ago, it was supposed that the capillaries take no part in normal or abnormal nutritive processes, excepting in so far as they act as passive filters through which liquor sanguinis transudes. This belief was first shaken by the discovery of Stricker that when the capillaries of the *membrana nictitans* of the frog are examined alive (*i. e.*, when the structure is placed under the microscope in aqueous humor immediately after excision), they exhibit changes of form and size which can only be accounted for by supposing them to be contractile.[1]

The activity of the life of the capillary wall has been more completely demonstrated by the further researches of the same pathologist, especially those carried out by him in combination with Leidesdorf, as to traumatic inflammation of the substance of the brain.[2]

In his first inquiry, published in 1866, Stricker showed that in the brain of the common fowl, when examined five or six days after mechanical injury, the vessels of the injured part exhibit changes which may be best described as consisting in budding or sprouting of the capillary wall. The structureless or hyaline substance of which the capillary appears to consist, is found to have undergone thickenings here and there of such a nature, that instead of being evenly cylindrical, it exhibits projecting irregularities or knobs. Of these knobs some retain their original form, while others grow out into branched or undivided processes, in a direction at right angles to that of the capillary, which sooner or later unite with similar outgrowths springing from other capillaries, so as to give rise to a connecting mesh-work of fibres. In the early state all these formations are beset with numerous fat granules, exactly similar to those which exist in the well-known exudation-corpuscles of inflamed brain substance; so that wherever the knobs are of a globular form, they look as if they were exudation corpuscles, embedded in and continuous with the substance of the capillary. Very recently these observations have been repeated by Dr. Jolly of Munich,[2] under Professor Stricker's guidance, who has found that the alteration of the capillaries begins within a day after the injury. The first change consists in an infiltration of the capillary wall with fat granules, and has its principal seat in the neighborhood of the nuclei. As the process advances, the granulation increases, and the alterations of form

[1] Ryneck, "Zur Kenntniss der Stase des Blutes in den Gefässen entzündeter Theile." Rollett's "Untersuch. aus dem Institute für Phys. u. Histol. in Graz." Leipzig, 1870, p. 103.

[1] Stricker, "Ueber die capillaren Blutgefässe in der Nickhaut des Frosches." Sitzungsberichte der Wiener Akademie, 1865, vol. li. part ii. p. 16. "Studien über den Bau und das Leben der capillaren Blutgefässe," loc. cit. vol. lii. part ii. p. 379.

[2] Leidesdorf und Stricker, "Studien über die Histologie der Entzündungsherde." Sitzungsb. der Wien. Akad., vol. lii. part ii. p. 534.

[3] Jolly, "Ueber traumatische Encephalitis." Stricker's Studien, 1870, p. 38.

already described begin to manifest themselves.

Although a similar process has not been made out in other tissues when in a state of inflammation, there are various facts relating to the condition of the capillaries in such tissues, which are in accordance with it. Thus in the process of healing by the first intention, the formation of new vessels takes place by a mode of budding from the old capillaries, which is very like that we have been considering. Little processes sprout out from capillary loops in the neighborhood of the wound, which are still entire, and grow towards similar processes which spring from other loops. The two growing points, as soon as they come into contact, melt together, just in the same way as the growing ends of the marginal filaments which we studied before in the plasmodium of the myxomycetes. Thus the main difference between the process of healing and that of traumatic encephalitis lies in the circumstance that in the latter the outgrowths from the capillaries are apparently not tubular, and do not become vessels. So also in the pyogenic membranes of very small abscesses, the newly formed capillaries, although they become looped, originate by outgrowth in the same manner.[1]

Since the discovery of the emigration of blood leucocytes, it has often been argued that their escape from the capillaries would not be possible unless the capillary membrane were porous; and then, this being admitted, the fact that the capillaries can be filled to distension with transparent injection masses (such as the so-called soluble Prussian blue) without the slightest extravasation, has been used as a reason for regarding migration as an impossibility. There seems to me to be no doubt that if the porosity of the capillaries were a necessary inference from the fact of emigration, the objection made would be a valid one. But from the account which has been already given of the vital properties of the capillary substance, the reader will see that any such assumption would be premature. The capillary is not a dead conduit, but a tube of living protoplasm. There is, therefore, no difficulty whatever in understanding how the membrane may open to allow the escape of leucocytes, and close again after they have passed out; for it is one of the most striking peculiarities of contractile substance that when two parts of the same mass are separated, and again brought into contact, they melt together as if they had not been severed.[1]

[The present accepted view of the histological structure of capillary bloodvessels rather infers the possibility of the migration of the blood-elements through openings or stomata.

The recent histological examinations of these vessels describe them as minute tubes composed of a thin elastic endothelial membrane, viz., a single layer of nucleated cell-plates. This endothelial membrane resembles other endothelial membranes, in that its cells are united one to another by an albuminous intercellular cement substance, which latter, in nitrate of silver preparations, is seen as dark irregular lines separating the cells.

The distension of the capillary vessels, which occurs during inflammation to an abnormal degree, is such as to cause a separation at many points of the intercellular cement substance. Thus we have formed minute openings (stigmata, Arnold), which are gradually enlarged into stomata. Winiwarter found, when such vessels were injected, that an escape of the injected substance may take place through these openings. If this condition exists during inflammatory action, it is very probable that diapedesis of colored and migration of colorless corpuscles may take place through these abnormal openings, the result of over-distension of the capillary bloodvessels.

Again, Purves has found that the capillary vessels, through which colorless corpuscles have migrated, upon being stained

[1] For a full description of this subject, see Wywodzoff. "Experimentelle Studien über die Vorgänge bei der Heilung per primam intentionem." Medizinische Jahrbücher, 1867, p. 3.

[1] "The griding sword with discontinuous wound
Passed through him, but th' ethereal substance closed
Not long divisible . . . . . .
. . . . . for spirits that live throughout,
Vital in ev'ry part, not as frail man,
In entrails, heart, or head, liver or reins,
Cannot but by annihilating die;
Nor in their liquid texture mortal wound
Receive, no more they can the fluid air.
All heart they live, all head, all eye, all ear,
All intellect, all sense; and as they please,
They limb themselves; and color, shape, or size
Assume, as likes them best, condense or rare."
Paradise Lost, Book vi.

Since the above was written I have had the opportunity of witnessing the very admirable and ingenious experiments lately exhibited at the Royal Society by Dr. Norris. A membranous film is formed by dipping a metal ring, a foot or more in diameter and held horizontally, into a vessel containing solution of soap. It is then shown that soap-bubbles, glass rods, and other objects with wetted surfaces, can be pressed through the film without its being ruptured. The conditions of this experiment are so entirely different from those which exist in the living tissue that I cannot regard it as affording any explanation of the passage of leucocytes through the walls of the capillaries.

with nitrate of silver, show that the migration is limited to the intercellular cement-substance of the endothelial wall.[1]]

V. SUMMARY.

We have now arrived at a point in our inquiry at which we may perhaps advantageously pause, and endeavor to bring the various parts of the process we have considered into closer relation with each other.

We have learnt that in inflammation the circulation is at first accelerated and increased, subsequently retarded and diminished, that the latter condition is attended with exudation of liquor sanguinis, emigration of leucocytes and stasis. In the study we have already made of these phenomena we have been led to believe that their origin is partly local, partly general. Thus, with respect to the leading vascular change in inflammation, viz., the acceleration of the blood-stream, it has appeared to be established on satisfactory grounds that it is a consequence of an impression received by the centripetal nerves of the injured part, and reflected by the vaso-motor centre through the centrifugal nerves to the vessels; so that although our understanding of the mechanism by which this result is brought about is as yet very imperfect, we can have little doubt that it is due to changes having their seat in the nervous system. On other grounds we have seen reason to suspect that most of the subsequent phenomena have no direct relation to the disturbance of the circulation as their cause, but rather to intimate changes in the properties of the living substance with which the blood comes into contact in its passage through the affected part. We shall probably best accomplish the end we have in view by assuming in the first instance that the essential phenomena of inflammation are referable either to disordered vascular innervation or to a local disturbance of the life of the inflamed part. We shall then be able to consider, with respect to each of them in succession, in how far it is referable to one or other of these proximate causes. The assumption, even if it do not turn out to be a true one, will materially help us in bringing facts into connection, and in determining their relative significance.

We have first to inquire into the causes of the slowing of the blood-stream which always succeeds the primary acceleration. Does it happen because the access of blood from the heart is retarded? or is it a combined result of the subsidence of the previous acceleration and of dilatation of the smallest vessels? The main reason for believing that it is due to diminished supply of blood from the heart, and therefore presumably to a condition of the arteries the reverse of that which leads to the previous afflux, is that in certain cases it is attended with visible narrowing of the arteries. The most positive observations on this point are those of Saviotti already referred to. He has made careful comparative experiments as to the vascular effects produced in the web of the frog by acids, alkalies, metallic salts, neutral alkaline salts, croton oil, cantharides, and other irritants; and he finds that in every case the diminution of the capillary circulation is attended with narrowing of the afferent arteries. Just as in the case of the previous dilatation, however, the relation between contraction of the capillaries and slowing of the blood-stream is not constant either as regards their degree or the time at which they occur. This want of correspondence is in itself sufficient to show that the former cannot be regarded as the cause of the latter. And we are the more disposed to adopt this view when we consider that the contraction can be completely accounted for otherwise. During the primary afflux of blood the arterial dilatation extends not merely to those branches which lead directly to the inflamed area, but to those which convey blood to its immediate neighborhood. Soon, slowing and stasis occur at the centre, the increased afflux still continuing, in consequence of which the collateral capillary channels become more and more enlarged. Eventually the arterial determination of blood subsides; less blood flows, but the capillaries still remain open, and therefore the artery which feeds them having less resistance in front, contracts to a diameter smaller than that which it originally possessed. In other words, notwithstanding the obstruction which exists at the seat of inflammation, the effect produced is not, as might be expected, dilatation, but contraction of the afferent artery, because the resistance is far more than balanced by the increased facility of circulation in the surrounding zone of congestion; so that the pressure of the blood against the inner surface of the artery and consequently its expansion, is considerably lessened. The diminished circulation in an inflamed part is therefore not to be regarded as a consequence of the diminished afflux of blood *a tergo;* for the narrowing of the arteries is a merely secondary effect of the disturbance of the circulation. We must, therefore, in accordance with the assumption with which we started, look in the direction of the local changes for its cause.

[1] Atlas of Histology. E. Klein and E. Noble Smith.]

It follows from what has been said that the slowing of the capillary circulation is merely the first stage of stasis, the beginning of the process of which stasis is the end. For if it be granted that they are both of exclusively local causation, it would be unreasonable to separate them; the more so considering that in all cases in which we have the opportunity of observation, the former is found to pass by insensible gradations into the latter. So far, therefore, as relates to the local changes in inflammation, *i. e.*, to those which occur within the range of the immediate action of the injurious stimulus, we see that the process consists first in gradual arrest of the capillary circulation, and secondly in exudation of certain constituents of the blood. When we proceed further to inquire in what relation these two stand to each other, by comparing the circumstances under which they are actually observed, we come at once to the conclusion that they are so closely and inseparably associated that neither can be considered as consequent or antecedent, and hence that both must be dependent on the same proximate cause.

In the present state of our knowledge it is not possible to elucidate the nature of this cause completely. There are, however, certain experimental facts which enable us to approach its solution somewhat closely, and which will, on this ground, serve as a basis for future investigation. Thus, if a ligature is tightened round the thigh of a frog, so as to arrest the circulation, and ammonia is applied to the web, the blood gathers from all sides towards the irritated part, until the capillaries within the area of irritation become choked with closely packed blood-corpuscles, and present all the appearance of stasis. If at the same time the other web is irritated in a similar manner, a comparison can be made of the effects produced. So far as the state of the capillaries is concerned, there is no difference whatever between them; the similarity becoming still more striking if the circulation is restored in the ligatured limb by removing the thread. Both webs then exhibit the ordinary results of irritation.[1]

In this experiment we have the process of inflammation reduced to its simplest form. Taken in combination with the observation of Dr. Ryneck, related in Part III., that neither exudation nor arrest of the capillary circulation can be produced in vessels through which certain poisonous metallic solutions have been passed, it shows that the agent in all the visible local effects is the living substance with which the blood comes into contact as it flows. Beyond this point we lose the guidance of direct observation, and must for the present content ourselves with stating that in an injured part the walls of the capillaries become so altered that the liquor sanguinis, instead of transuding from the smaller arteries in quantity just sufficient to balance the absorption, leaks abundantly from the vessels; and that in many cases this is subsequently associated with squeezing out of the leucocytes, or even of the colored corpuscles.[1]

What the nature of this sudden change in the living substance is, we know not, and should gain nothing by speculating. Apart from all theory the fact stands out clearly that, independently of any visible alteration either in the vessel itself or in the structural elements in its neighborhood, the constant effect of injuring a living tissue is to divert a part of the liquor sanguinis from its natural course, and determine its soakage from the vessels which before held it, into the surrounding parenchyma.

Another question presents itself, the consideration of which cannot be left out, although it does not at present admit of any satisfactory answer, viz., that of the immediate cause of the emigration of leucocytes, and the relation of this phenomenon to exudation of liquor sanguinis. Why, as the blood-stream slackens in an inflamed part, leucocytes should separate from it and tend towards the internal surfaces of the veins and capillaries, we must admit ourselves altogether unable to explain. The fact that if blood freshly taken from the circulation of a frog or newt is received in a capillary tube or under a cover-glass, the leucocytes emigrate from the clot as soon as it is formed, and collect in numbers in the surround-

[1] This experiment was first made by H. Weber in 1852 ("Experimente über die Stase an der Froschschwimmhaut." Müller's Archiv, 1852, p. 361). It was repeated by Prof. Lister (loc. cit., p. 667) in 1857, and subsequently by other pathologists.

[1] That the change by which the capillaries become leaky has its seat in the vascular walls rather than in the adjoining tissue, is rendered probable by a recent observation of Dr. Ryneck, who has found that if an irritant is applied to the web of a frog, in which solution of common salt is circulating instead of blood, it becomes infiltrated at the seat of irritation to such an extent that a prominent tumor is formed, which eventually spreads over the whole of the division of the web acted upon. This experiment shows that exudation cannot be a consequence of increased attraction between the tissue and the circulating liquid, for in the case of salt solution such an attraction cannot be supposed to exist.

ing serum, affords an opportunity of watching the process under conditions much simpler than those which exist in the circulation.[1] As yet we are as little able to explain the one as the other. There can, I think, be little doubt that of the two stages in the process of emigration, viz., the long-known loitering of leucocytes along the sides of the vessels, and the newly-discovered penetration by them of the vascular walls—the first is the essential one, and that whenever an explanation is found of the former, it will serve as a key to the comprehension of the latter.

Section II.—Changes which have their seat in the tissues.

Introduction.

In the preceding section we have seen that the process of inflammation centres in the discharge of liquor sanguinis from the capillaries. We have now to consider the influence which the exuded liquid exercises on the elements of the tissues. The textural changes, although they may differ considerably according to the structure and function of the part affected, are all of such a nature as to indicate increased activity of cell life. Considering that the condition of an organ which is the seat of inflammation differs, so far as observation teaches us, from the ordinary state only in being soaked with exuded liquor sanguinis, it is natural to attribute the supervening over-growth and over-multiplication of cells to the exudation. As, however, many pathologists believe that these effects have an extremely different signification—that they are the results not of the direct stimulation of the cells, but of impressions reflected to them by an unknown nervous centre, supposed to preside over nutrition—we shall, after we have completed those anatomical descriptions which will constitute the most important part of the present section, place before the reader the grounds which exist for believing that whatever other influences may co-operate with that of changes in the nutritive medium in which the tissues are immersed, this is in itself sufficient to account for the textural germination.

I. Structural changes which occur in the connective and supporting tissues in inflammation.

Under this title I include all those tissues which are not concerned in any function excepting those expressed in the definition. With reference to the present inquiry they are divisible into vascular and non-vascular. The vascular tissues include bone and the varieties of connective tissue in the strict sense; the non-vascular, cartilage, tendon and the cornea.

Non-vascular connective and supporting tissues.

In studying the process of inflammation in tissues which derive their supply of nutritive material from bloodvessels at a considerable distance, we have the great advantage of being able to separate entirely those phenomena which are proper to the tissue-elements from those which belong to the circulation. For this reason it is not surprising that the non-vascular tissues have at all times, since the earliest attempts to apply exact methods of research to pathology, been favorite fields for this investigation, and that of late years in particular, the most fruitful and at the same time decisive discussions which have taken place have related to the structural changes produced by artificial irritation in the cornea.

Inflammation of the cornea.—The reader who desires to know more of the earlier researches relating to traumatic keratitis will find the information he requires in special treatises on that subject. For the elucidation of the question which now engages our attention it appears scarcely necessary to carry our inquiries beyond the past ten years; for the better modes of investigation which have been introduced since 1863 by v. Recklinghausen and Cohnheim have given to subsequent observers so great an advantage over their predecessors, and placed the subject in a light so entirely new, that it has become necessary to begin the work afresh. The result has been to confirm the truth of the previous discoveries and to establish the doctrine of textural pyogenesis, which was so admirably developed in the article on the process of inflammation contained in the previous edition of this work, on a more solid and extended basis.

Professor von Recklinghausen's method of examining the cornea of the frog is as follows:[1] The anterior chamber is first punctured so as to let out a drop of aqueous humor, which is placed on the object-glass; the cornea is then excised and placed in the drop with Descemet's membrane uppermost. The preparation thus obtained is examined without a cover-glass, in a closed chamber in which the air is saturated with moisture, so that no

[1] For a description of this process, see my lecture on Leucocytes, already quoted.

[1] V. Recklinghausen, loc. cit. p. 157.

evaporation can take place, and consequently no alteration in the density of the liquid in which the cornea is immersed.[1] The healthy cornea is absolutely transparent, and when it is examined under the microscope in the manner described, no structure can be distinguished. This homogeneity, so essential to the function of the cornea, is a condition inseparable from life; if the observation is continued till the tissue begins to die, its structural elements gradually come into view—first the epithelia, then the lymphoid elements proper to the tissue, then the cornea-corpuscles. The explanation of the fact is, that whereas in life the elements of which the cornea is formed, affect light exactly in the same degree, their respective refractive powers are slightly altered in the act of dying.

If a cornea is examined in the same way, which has been irritated a quarter of an hour before by the application of a point of caustic to its surface, the conjunctival epithelial layer can at once be distinguished, along with a few leucocytes, underneath and among the epithelial elements. If an hour or two has elapsed, the proper cornea-corpuscles are visible, as dark stellate or spindle-shaped spots on a transparent ground. Of these some are homogeneous, and can be distinguished from the surrounding substance by a slight difference of shade. In others, which are finely granular, the processes or rays are subject to slight variations of contour. These amœboid movements of the rays, although very sluggish as compared with those of young protoplasm in general, are rendered much more active by subjecting the preparation to a stream of blood-serum; for which purpose Professor Stricker employs the serum of the same animal which has furnished the cornea.

In order to follow the inflammatory process in its further stages, another method of preparation has been found by Stricker to be advantageous. The cornea is immersed for a few minutes in a weak solution of chloride of gold ($\frac{1}{2}$ per cent.). It is then washed with water slightly acidulated with acetic acid, and exposed to daylight. When the frog's cornea is examined in this way at various periods after irritation, the progress of the changes of which the beginning has been already sketched, may be studied with great advantage. In the normal cornea, when so treated, the stellate corpuscles with their nuclei can be very distinctly seen. The latter are irregularly defined, of large size in relation to the protoplasmic mass in which they are embedded, and contain one or two nucleoli. In the stellate masses themselves the caudate processes or rays are the most striking and obvious features. In a cornea excised three hours after irritation, some of the corpuscles exhibit no change excepting that their outlines are more strongly marked; in others there seem to be, in addition to the irregular nucleus above referred to, one or more spheroidal bodies which are embedded in some other part of the corpuscle. This

Fig. 5.

Cornea of frog excised three hours after irritation.

appearance affords the earliest sign that the process which has been hitherto called "proliferation" is beginning, that is to say that the mode of life of the protoplasmic mass is changing from the normal quiescent state which fits it to take part in a permanent tissue, to the state of reproductive or germinating activity—that new bodies are being formed within the body of the parent mass, to which such terms as "germs" or "offspring" are applicable. A part of the original living substance of the element begins a new life, much more active than it before possessed, and a new organic development. Since the introduction of the method of observing structural changes in living tissues, pathologists have learnt that it is a constant characteristic of the change we are considering, that the rejuvenescent part or substance acquires the property of contractility. In other words, that all protoplasm when assuming new life, and beginning new organic development is endowed with the faculty of amœboid movement. Of the words which have

[1] The following statement is founded on the admirable research of Mr. W. F. Norris, conducted in the Vienna laboratory under Stricker's guidance. Norris and Stricker, "Versuche über Hornhaut-Entzündung." Stricker's Studien, 1870, p. 1. I retain the terms employed by the authors, although in the light of more recent anatomical discoveries they are open to criticism.

been employed to denote this change, viz. rejuvenescence, proliferation, germination, the last appears preferable as being the least technical and the most expressive.

We return to the further steps of the germinative process in the inflamed cornea. Between the fifth and twelfth hours after irritation the cornea-corpuscles become more and more distinct and granular, while their processes become thicker and shorter, until at length many of them lose altogether their characteristic stellate

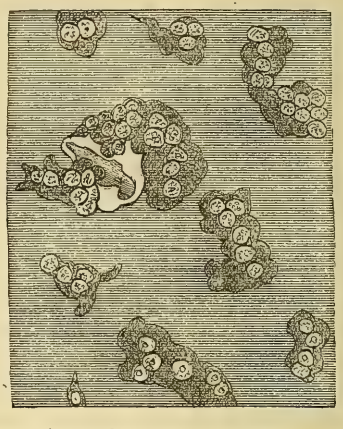
Fig. 6.

Altered corpuscles of cornea excised eight hours after irritation.

or caudate outline, and are converted into irregular clumps. If the cornea is examined in this stage, after treatment with chloride of gold, it is seen that in those parts in which the structural changes are most advanced the normal character of the tissue is entirely lost. The beautiful network produced by the interlacing of the normal corpuscles is no longer visible; in place of it the field is scattered over with clumps of irregular form, in some of which the caudæ are represented by rounded knobs, while in others the outline is almost spheroidal. Most of these bodies are so granular that their contents cannot be distinguished, but in others the newly formed germs are plainly visible. The number of these germs varies according to the stage of irritation, so that in the same cornea, clumps containing a numerous offspring may be seen in one part, while in others the germination is only beginning.

That the interpretation suggested by these appearances is the true one, that the clumps containing numerous round corpuscles are really of the nature of mother-cells, the observer can best assure himself by returning to the method of examination first described, that is to say, by placing the inflamed tissue under the microscope alive, at the same time stimulating the elements in question to increased amœboid movement by irrigation with serum. It is then seen that the germs change their relative position with

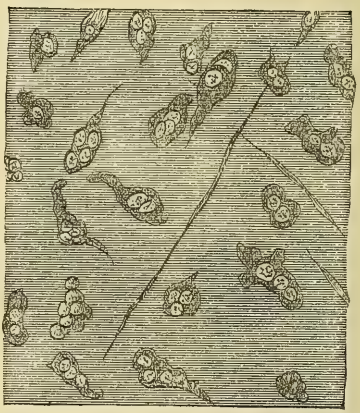
Fig. 7.



Cornea sixteen hours after irritation. Amœboid masses containing numerous newly-formed elements.

the movements of the mass of protoplasm in which they are inclosed, just in the same way as the granules and ingesta do in the body of an amœba, rolling one

Fig. 8.



Cornea about twenty-four hours after the insertion of a fine ligature. Masses containing young elements in the neighborhood of the thread.

over another in such a manner as would not be possible if they were not really contained in the mass.

Hitherto nothing has been said of pus-corpuscles, that is, leucocytes, because in the stages of keratitis we have been considering they bear no part. The cornea has lost its perfect transparency, but is

not as yet turbid; the few leucocytes which are met with are those which are indigenous in the tissue. There is as yet no suppuration; to arrive at an opinion as to how the formation of pus commences we must follow Professor Stricker a stage further. The difficulty of the observation lies in the rapidity with which the process takes place; for from the moment that the cornea begins to be clouded, its tissue is so beset with growing and multiplying elements that it is difficult to distinguish them, so that the only way by which a conclusion can be arrived at is by combining the results of a number of observations made on different corneas at the stage of commencing opacity.[1] From such observations it may be learnt, first that the opacity is due to the presence of leucocytes, which are so numerous that it is out of the question to regard them as the offspring of those which are indigenous in the tissue; and secondly, that among them there are many of the original branched or stellate corpuscles, some of which are only slightly changed in outline or aspect. But in addition to these more or less normal corpuscles, the masses above described, containing groups of germs, also occur in great numbers, while among them, and in the very parts of the cornea where they are most numerous, the leucocytes are most crowded and there are fewest fixed corpuscles. If these are facts it can scarcely be doubted that there is a relation between the metamorphosis of the stellate corpuscles and the formation of leucocytes; in short, that the little spheroids which are contained in the amœba-like masses are young pus-corpuscles, and that even in the cornea suppuration must be regarded as at all events in part, a process of germination.

We have next to consider to what extent emigration is also concerned in traumatic keratitis. According to Professor Cohnheim, it is the only way in which the pus-corpuscles are produced, this conclusion being mainly founded on negative observations. He has failed to observe the germination process we have been describing, and does not believe in it. He finds that in every form of traumatic keratitis, whatever be the nature or mode of application of the irritant, the stellate corpuscles remain absolutely unaltered, both as regards their position and arrangement, and their structure, and that the leucocytes to which the opacity is due are neither inclosed in other elements nor show any indication of being in different stages of development; whence he naturally concludes that they cannot have originated where they are found, and must have been introduced from outside. He has further observed, and the fact has been confirmed by many other pathologists, that if keratitis is produced in a frog whose blood-leucocytes have been charged or fed with aniline or vermilion by injecting either of these pigments in a state of extremely fine division into the circulation, corpuscles can be distinguished in the inflamed cornea, which from their being pigmented must necessarily have migrated from the blood. [According to Cornil and Ranvier, this conclusion of Cohnheim's that "the pigmented corpuscles must necessarily have migrated from the blood," does not appear to them justifiable; since after irritation, the cornea may become infiltrated by a large quantity of fluid from the blood. This fluid holding in suspension the colored particles of aniline, comes in contact with the various cells of the cornea; the granules may then penetrate them directly. Thus it is possible to set up, in place of the theory of Cohnheim, the hypothesis of the direct penetration of particles of aniline into pus-corpuscles which may be generated in the cornea.] In some cases the marginal part of the cornea, that part which of course is nearest to the vessels, is so full of immigrant leucocytes that the blue or red coloration can be distinguished even with the naked eye. These facts, of course, afford conclusive evidence of migration, but they contain no disproof of tissue-germination, for even Professor Cohnheim himself admits that in all stages of the process there are many leucocytes which are not colored.

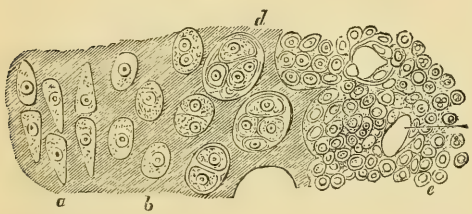
The only positive argument against germination is that founded on the remarkable experiment known as that of the "salt frog." This experiment consists in slowly injecting a weak solution of common salt by the abdominal vein, until blood ceases to flow from its peripheral end which is left open, so that the whole of the natural circulating fluid is replaced by the saline solution. In this condition the animal may be kept alive for several days. If, then, immediately after the injection, the cornea is irritated, no opacity is produced, because, according to Cohnheim, the blood from which they spring is absent. During last summer this experiment was carefully investigated in the Vienna Pathological Laboratory. It was found that even if the injection is continued, according to Cohn-

[1] The reader who is acquainted with Professor Cohnheim's researches on keratitis will notice that they commence at the point to which we have now reached, so that it is not difficult to understand that, although he employed the same modes of examination, he failed to observe the structural changes which have been described in the preceding paragraphs.

heim's direction, until the liquid which issues from the open end of the vein appears colorless, the minute capillaries as seen in the mesentery still contain liquid which is rich in leucocytes, so that whatever be the explanation of the want of opacity of the cornea, it is not due to the absence of these structures from the circulation; it is much more reasonable and natural to suppose that the result of the experiment is to be accounted for by the peculiarly abnormal condition of the animal.

Inflammation of cartilage.—The changes which occur in the permanent structural elements in consequence of irritation, are much more easily studied in cartilage than in the cornea, on account of the facility with which this tissue can be prepared for microscopical examination; it has therefore from the commencement of the inquiry afforded to the pathological observer the most accessible evidence in support of the belief that such structural changes form an essential part of the process of inflammation; and particularly as regards the question of the origin of pus, the obvious difficulty of supposing that the young elements which occupy its cavities when it is inflamed have penetrated into those cavities from some other quarter, has made the case of cartilage the strongest that can be cited against any exclusive doctrine of emigration. For this very reason it is unnecessary to devote much space to the discussion of inflammation in cartilage, for it is certain that if we can show that germination is the rule in every other tissue, no one will suppose that cartilage is an exception. The normal cartilage cell, like every other active cell, is a mass of protoplasm containing a nucleus. As in the case of the cornea, each mass is inclosed in a cavity of similar form to itself, which is hollowed out in the interstitial substance; the difference being that whereas in the cornea the cavities communicate with each other by the innumerable tubular prolongations which correspond to the rays of the stellate cells, in cartilage they have no such prolongations and are entirely closed. When cartilage is irritated, as for example by scraping its surface, the cells in the neighborhood of the irritation enlarge and consequently expand their capsules. The protoplasm of which each cell consists becomes more granular, and soon it is found that the mass contains two corpuscles in its interior instead of one, and that each has a gathering of protoplasmic matter around itself. This process of division is repeated in each segment until every cavity contains a mass of nucleated cells, which at length assume characters corresponding with those of newly formed pus-corpuscles, while at the same time the original interstitial substance gradually wastes away, and is finally represented by a sponge-like stroma, in the holes of which the groups of young cells are contained. In this process we have a typical example of germination; the permanent cells which have for their function the maintenance of the unchanging life of the tissue, are replaced by a more numerous progeny of transitory mobile cells, *i. e.*, leucocytes, which live at the expense of what remains of the tissue and eventually destroy it.

[Fig. 9.



Section of inflamed cartilage. *a*, The normal cartilage cells. *b*. The same enlarged. *d*. Multiplication of cells within their capsules. *e*. Great increase in the number of the young cells, and destruction of the intercellular substance × 250.—(From Cornil and Ranvier.)]

Inflammation of tendon.—As a non-vascular tissue, extremely rich in cellular elements, tendon has almost as great advantages as cartilage for the study of the inflammatory changes which such elements undergo at a distance from the vessels. The splits (*Henle'sche Spalten*) which exist in tendon between the parallel bundles, are lined with chains of staff-shaped, nucleated cells, each of which is in contact with its neighbors by its ends, and consists of a cylinder of protoplasm, including a nucleus. The changes which these cells undergo have been recently very completely studied in rats and guinea-pigs by Dr. Güterbock, who finds that by a kind of cleavage of the nucleus that body assumes a botryoidal or necklace form, to which the scanty covering of protoplasm models itself. Eventually new cells (young pus-corpuscles) are formed by the complete division of the nucleus. Here, as in other cases, the participation of the elements of the tissue in the germinative process, can only be judged of at the very beginning, *i. e.*, about eight hours after the injury. At a later period it is so difficult to distinguish the results of similar changes in the connective tissue from those proper to the tendon itself, that no conclusion can be arrived at.[1]

[1] Güterbock, "Untersuchungen über Sehnenentzündung." Stricker's Jahrbücher, i. p. 22.

Vascular connective tissue.

The most positive information we possess as to the nature of the inflammatory changes in vascular connective tissue is derived from the examination of the process in a frog's tongue, for there is no other organ in which the tissue in question can be placed under the microscope under conditions so completely normal. The mode of experiment has been already referred to.

The textural changes have been lately described with great minuteness by Professor Cohnheim,[1] and still more recently his description has been critically examined by Professor Stricker.[2] The curarized frog is conveniently placed on its back, the tongue being extended by a ligature attached to each of its two tips, and the ligatures so fixed that the organ can be set free and replaced in the mouth at the end of each period of observation. The tongue can thus be placed readily under the microscope, with its papillary surface upwards. As, however, the submucous tissues could not be well seen through the mucous membrane, it is desirable to strip this membrane off, over a small extent of surface, an operation which can be effected with scarcely any bleeding, and has the additional advantage that it affords a convenient and practical method of irritating the parts to be examined. If these preliminary arrangements have been successfully carried out, and sufficiently high powers are employed in the examination, it is seen that in the meshes between the capillaries of the intermuscular spaces there are bodies of the most varied form and slightly turbid appearance—the so-called connective-tissue-corpuscles. According to Cohnheim these bodies take no part whatever in the inflammatory process, the steps of which, as he observed it, correspond to those we have already described when speaking of inflammation in the mesentery. To determine this question, of such importance in its general bearing on inflammation of connective tissues, Professor Stricker has subjected these corpuscles to the closest scrutiny. He finds that while some of them are oblong or fusiform, others are of the extremely irregular form figured by Cohnheim, and that corpuscles of the latter class may be watched for hours (in one instance in the same individual for ten hours continuously) without changing their place. But he does not admit that they are motionless; on the contrary, he states that they undergo changes of form of so marked a character, that there can be no mistake about their existence. Thus they swell at one part, shrink in others, sometimes budding out into processes, which are again retracted; at others assuming forms which seem to indicate that they are on the point of dividing. Yet notwithstanding the most careful and patient observations, Stricker has not succeeded in seeing a single act of division completed. In the oblong corpuscles the amœboid changes are less active, and limited to the extremities. Sometimes it was observed that the tip gathered itself up as if it were just about to separate from the rest, but again subsided into its original condition.

FIG. 10.

Connective tissue corpuscles of the tongue of the frog.

In several of Stricker's experiments the process of emigration was going on with great activity, and the tissue becoming fuller and fuller of leucocytes during the whole period that he was engaged in observing the phenomena above described in the connective-tissue-corpuscles. It therefore appears perfectly clear that, in the particular case of the tongue of the frog, these corpuscles have at first nothing to do with the process of suppuration. On the other hand, it seems highly probable that if it had been possible to pursue the investigation to a later stage, the changes of form which he describes would have resulted in actual division. The lesson to be learned here, as in other cases, seems to be, that although in acute and rapid suppurations the leucocytes are mostly if not all emigrants, there is reason to believe that at later periods other modes of pyogenesis come into operation. At the same time it must be borne in mind, that in the present state of our knowledge this is rather a matter of inference than of observation. The grounds for believing it are in the first place the facts we have already considered with reference to the cornea, and secondly the structural alterations which are met with in examining tissues in the more advanced stages, and

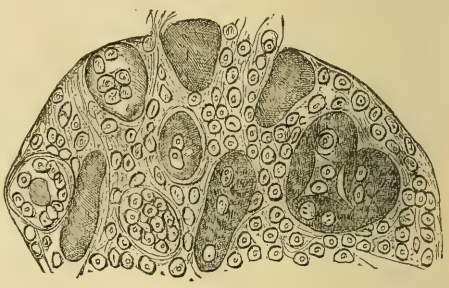
[1] Cohnheim, loc cit. p. 344.

[2] Stricker, "Ueber die Zelltheilung in entzündeten Geweben," loc cit. p. 18.

less acute forms of inflammation—all those anatomical facts, in short, which formed the original groundwork of the doctrine hitherto taught of the textural origin of pus; with reference to which many of Cohnheim's followers seem to have forgotten that they are quite as true and quite as significant as ever. For in every limited inflammation of the subcutaneous tissue, and in the neighborhood of every subcutaneous abscess, a region is found outside of the focus of suppuration, in which the connective-tissue-corpuscles present alterations which are so distinct, that it is impossible for any one who is conversant with them to doubt that they signify that the tissue is germinating.[1]

Inflammation of muscle.—There is no vascular tissue in which the phenomena of germination can be more satisfactorily studied than in muscle. The process was first examined by Waldeyer, and subsequently by Otto Weber (Fig. 11). Still more recently it has been made the subject of an extended series of experiments by Dr. Janovitsch Tschainski,[2] under the direction of Professor Stricker. In traumatic inflammation of muscle, the fixed corpuscles of the fibre-sheaths undergo

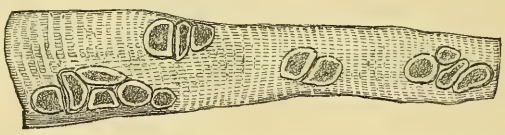
Fig. 11.



Cross section of human muscle from the neighborhood of a wound. The dark masses represent the remains of muscular bundles. In other parts of the section the sheaths are filled with young elements, which have displaced the muscular substance. The interstitial connective-tissue is also in a state of germination. (After Otto Weber.)

alterations which resemble those we have already noticed in connective tissue, and,

Fig. 12.



Multiplication of nuclei in the sheath of an inflamed muscular fibre.

as in other cases, they are much better seen in parts at a little distance from the seat of injury than in its immediate neighborhood. Thus, in experiments in which muscle was cauterized, Dr. Janovitsch found that the inflammatory changes could be studied most advantageously in the outer zone of redness and swelling. In this situation the muscular substance, when examined twenty-four hours after irritation, is found to be for the most part unaltered, the transverse striæ being well marked and of natural appearance. The aspects of the corpuscles vary according to the stage of change. Some are merely enlarged, each consisting of a single nucleus embedded in a fusiform clump of finely granular protoplasm. Of the rest

Fig. 13.

Empty sheath beset with young elements.

some exhibit two nuclei, others a greater number, which are arranged either in a heap or in a series, and are generally so close to each other that their opposed surfaces are flattened, the whole being held together and surrounded by the protoplasm already mentioned. In the later stages the young elements multiply to such an extent that they eventually occupy the whole of the sheath, the natural contents having gradually disappeared.

[1] The experiment of M. Lortet, already referred to (p. 46), affords the pathological student the opportunity of satisfying himself, by a single observation, that in traumatic inflammation of the subcutaneous cellular tissue, pus is formed both by tissue-germination and emigration. The swimming-bladder of a fish, previously filled with solution of common salt, is inserted beneath the skin of a rabbit. After thirty-six hours the animal is killed, and the lesions are investigated. It is then seen that while the bladder is full of corpuscles which can only have migrated from the bloodvessels, there is abundant evidence of the commencement of germinative pyogenesis in the surrounding texture.

[2] "Ueber die entzündlichen Veränderungen der Muskelfasern." Stricker's Studien, p. 86.

II. STRUCTURAL CHANGES WHICH OCCUR IN THE EPITHELIAL AND GLANDULAR TISSUES IN INFLAMMATION.

Epithelial tissues.—The appearances observed in suppurating mucous membranes have always been regarded as affording, next to those in the cornea and in cartilage, the strongest evidence of the textural origin of pus. For in a great many kinds of catarrh, large cells have been met with in the purulent liquid which is thrown off at the very commencement of the process, which contain groups of bodies entirely resembling young pus-corpuscles. These remarkable epithelial elements were considered by Buhl,[1] who first described and studied them, as mother-cells or blood-cells; and most pathologists since have regarded them in the same light. But more recently, since the discovery of emigration has induced a tendency in the minds of some persons to conform all the details of the inflammatory process to one type, Steudener and Volkmann[2] have maintained that the bodies in question are not the offspring of the cells in which they are inclosed, but strangers which have intruded themselves from without. Here, as in so many other cases, the only way of solving the question was, if possible, to observe the phenomena in the living tissue, *i. e.*, to see the process of intrusion or extrusion actually going on under the microscope. This, however, was evidently a matter of great difficulty. In Professor Billroth's[3] admirable essay on inflammation the reader will find an account of a number of efforts made by him for the purpose without satisfactory results. The question seems, however, to have been now settled in favor of the original doctrine of Buhl, by the very recent researches of Dr. Oser[4] in the Vienna laboratory.

Although in general epithelial structures derive their nourishment directly from the blood, there are some which are entirely remote from vessels. Of these the epithelium covering the cornea and that of the epiploa are the best examples. If the normal epiploon[5] of the rabbit or guinea-pig be treated with weak solution of nitrate of silver, and then exposed to the light and examined without further preparation, it is seen that in the most delicate parts it consists merely of a network of hyaline fibres of connective tissue paved on both sides with flat epithelia; and that in the centre of most of them a little mass of protoplasm can be distinguished. We have here, therefore, an

[Fig. 14.

Normal omentum stained with nitrate of silver. × 250.—(From Cornil and Ranvier.)]

epithelial structure of the simplest kind which is entirely out of relation with the capillaries, and is thus remarkably well fitted for studying the independent behavior of epithelial elements in serous inflammation. If a little iodine or solution of nitrate of silver be injected into the peritoneum, and the omentum be examined twenty-four hours after, it is found that the fibres of the network are no longer covered with a continuous pavement, but that a number of elements hang about it, most of which differ considerably from the original epithelia, though some still resemble them. The most striking difference is that of the increased size of the protoplasmic mass.

[Fig. 15.

Omentum artificially inflamed, and silver treated. *a*. Proliferating endothelial cell. *b*. Pus-corpuscle. *g*. Endothelial cells, becoming spherical and prominent in process of detachment from the fibrous trabeculæ. *t, f*. Swollen, but still adherent endothelial cells. × 250.—(From Cornil and Ranvier.)]

Instead of a faintly granular body scarcely so large as a leucocyte, you have a clump twice or three times as large, which if examined under the proper conditions displays amœboid movements. Some of these rapidly growing cells contain single nuclei, others two or a greater number of spheroidal corpuscles corresponding in form and size to those which either float free in the peritoneal liquid, or are inclosed in the coagulum of reticular fibrine with which the affected surface is more or less covered.

[1] Buhl, Virchow's Archiv, vol. xvi.

[2] Centralblatt, 1868, No. 17.

[3] Billroth, "Mancherlei über die morphologischen Vorgänge bei der Entzündung." Medizinische Jahrbücher, vol. iv. 1869, p. 1.

[4] Oser, "Ueber endogene Bildung von Eiterkörperchen an der Conjunctiva des Kaninchens." Stricker's Studien, p. 74.

[5] Cornil et Ranvier, Manuel d'Histologie pathologique. Paris, 1869, p. 74.

In this case it is at all events certain that some of the changes observed have nothing to do with migration, for the membrane in which they occur is non-vascular. But it is obviously only a matter of inference, that we have before us an actual formation of pus by epithelial germination. We shall find, however, additional ground for believing that this interpretation is the true one, by comparing the account given above with the very exact observations of Dr. Oser on the conjunctiva already referred to. In his experiments the membrane in

Fig. 16.

An epithelial element from the anterior surface of the cornea of a rabbit, which had been irritated two days before with weak ammonia. *a a*. Nuclei. One of the five young elements contained in the central cavity is in the act of escaping through the wall of the cell.

question was examined at periods varying from a few hours to four or five days after irritation with solution of ammonia of various strengths. The first stage of the process consists in the growth of the protoplasmic or living part of the epithelial element, and the consequent disappearance of the external investment; the second in the condensation of the granular material at one, two, or a greater number of points, into little spheroidal corpuscles, which as they become more distinct appear to detach themselves gradually from the remaining granular matter, until eventually they all lie free in one cavity. Finally the spheroids show themselves to be leucocytes by their amœboid movements; and, on one fortunate occasion, were seen by Dr. Oser making their way out of the mother-cell and then moving about in the surrounding liquid.

In both the cases referred to, it is to be borne in mind that the fact of germinative pyogenesis does not exclude that of migration. Indeed, as regards the serous membranes, there is the strongest reason for believing, that in certain forms of acute peritonitis the leucocytes contained in the peritoneal liquid are all emigrants. Thus in the peritonitis which is produced in the frog's mesentery by exposure, it is quite impossible to suppose that the dense layer of corpuscles which, in the advanced state of the experiment, covers the surface of the membrane, can be derived from any other source than the circulating blood. Again, the anatomical appearances which present themselves in the most acute forms of suppurative peritonitis with which we are acquainted clinically, even though we may be disposed to admit that they might be brought into harmony with an opposite theory, can be explained much more naturally and easily in the same way.

Glandular tissues.—The question next to be considered is that of inflammation of glands. There is no glandular organ in which traumatic inflammation has been so completely studied as in the liver; some observers finding, in the anatomical changes which result from experimental irritation, proof of the dependence of these changes on migration, while others, particularly Holm, believe that the liver-cells undergo transformation into inflammatory products, and that pus-corpuscles may be produced in hepatic mother-cells. Dr. Hüttenbrenner has recently repeated the experiments of Holm,[1] as well as those of Köster[2] (who may be regarded as the most important expositor of Cohnheim's doctrine in its relation to inflammation of glands), and has confirmed the results obtained by both of his predecessors. He concludes that in the liver, if the irritant is such as to produce alterations which are confined to the immediate neighborhood of the injury, the liver-cells germinate, and believes that the few pus-corpuscles which are formed under these circumstances originate endogenously. If, however, an abundant suppuration is produced, as *e. g.*, by the injection of ammonia, it is found that the pus-corpuscles are collected round the bloodvessels in a manner which certainly indicates that they are emigrants, or that the capillaries are concerned in their production. In support of the same view we may refer to the observations of Billroth[3] on mastitis and orchitis. In a patient who died in puerperal fever with minute abscesses disseminated throughout the mammary gland, Billroth found that the young pus-cells occupied the inter-acinar vascular network just in the same way as Köster described in the liver. Again, in an inflamed testicle taken from a patient who had died of secondary pyelitis consequent upon stricture, and had often before been treated for gonorrhœal orchitis, the connective tissue between the seminal canals was the seat of interstitial irritation, and beset with an infinite number of young cells, the glandular structures remaining themselves unaltered. In both of these

[1] Holm, "Experimentelle Untersuchungen über die traumatische Leberentzündung." Wiener Sitzungsb. vol. lv. part II. p. 439.

[2] Köster, "Entzündung und Eiterung in der Leber." Centralblatt, 1868, p. 17.

[3] Billroth, loc. cit. p. 30.

cases the accumulation of leucocytes round the vessels is certainly remarkable. But before we agree to the explanation offered by Billroth we must take other considerations into account. It is to be borne in mind, that in both instances the inflammation was of a secondary, that is to say infective, character. In all inflammations of this class it appears quite as reasonable to suppose that the limitation of the morbid changes to the immediate neighborhood of the bloodvessels is due to the fact that the infective agent is introduced into the tissue by the blood-stream, as to attribute it to emigration of leucocytes.

For the present this question must remain open. All that we are justified in concluding is, that although even gland-cells under certain circumstances may be alienated from their natural secreting function, and excited into reproductive activity, this germination does not play any important part in the formation of pus.

["According to Durante (Wien. Med. Jahrb., 1871), in inflammations of the vein-walls, endothelium, muscular cells, and connective-tissue-nuclei participate in the proliferation. The intima shows first an irregularly distributed increase of inter-cellular substance; later the inter-cellular substance increases in the whole periphery of the endothelial cells, these even become oval or round, the body of the cell becomes granular, the nuclei show marks of division: two, four, six, eight of them appearing in one cell. The cells now show either Oser's endogenous cell-formation; or the cleft nuclei crowd against the periphery of the cells. Small elevations, buds, make their appearance, in which, during the gradual separation, the nucleus remains inclosed; finally, there are to be observed in the midst of the intercellular substance a great number of such cells, whose origin is by germination, or at least by a process bordering upon it. The changes in the adventitia are not to be distinguished from those of common connective tissue in inflammation. The connective-tissue-cells swell, and assume an oval, round, or irregular shape; later, their nucleus divides into two, three, or more parts, which is afterwards followed by a division of the cells themselves. The smooth muscle-fibres show a proliferation of their nuclei and division of the spindle-cells themselves into smaller segments."

"Klein and Burdon-Sanderson observed in rabbits and guinea-pigs, on the inflamed peritoneal side of the diaphragm, that the endothelial cells put forth buds which became separate as young amœboid cells. Similar observations have been made on other serous membranes."

"According to Ranvier (Nouv. Dict. de Méd. et de Chir. prat., 1870), the laminated pavement epithelium of serous membranes, bloodvessels and lymphatics, of the alveoli of the lungs and glomeruli of the kidneys, as well as the flat cells of connective tissue, under the influence of inflammation return to the embryonic state, and after the disappearance of the inflammation, these embryonic cells again form the original tissue."[1]

Cornil, in his Leçons sur le Syphilis, when describing the changes which take place in the epidermic layers of the skin, at the seat of an infecting chancre, says: "Some of the cells of the deeper corneous layers or of the granular layer present a small cavity which is formed around the nucleus of the cell, between the nucleus and solid part of the cell. The nucleus may be atrophied and flattened in the cavity formed in the middle of the cell, or it is enlarged and budding, and the cavity may contain two or three round and granular nuclei." Further on, he writes: "that the pus corpuscles are formed in the excavated epidermic cells by a division of the pre-existing nucleus and by an endogenous generation."]

III. INFLUENCE EXERCISED BY THE FORM AND MODE OF ACTION OF THE INJURIOUS AGENT ON THE CHARACTER OF THE RESULTING TEXTURAL CHANGES.

Although, if we be careful to distinguish what is essential to the process of inflammation, viz., the altered state of the vessels, from the phenomena which accompany it, and the textural germination which it produces, its character will appear to us to present very slight variation, yet the visible results by which it manifests itself differ widely in different cases. It is therefore necessary, in order to complete the present subject, to consider in what degree these differences correspond to differences in the causes which produce them.

Vesication.—If a hot iron is applied to the skin at a sufficient temperature, it at once destroys its vitality. If the temperature be a little below that which is necessary to produce this result, the blood contained in the vessels coagulates, and the tissue eventually dies. At a still lower temperature the skin retains its vitality, but blisters are formed at or around the injured part.

If the mesentery of a guinea-pig is touched with a heated surface, and the effect observed under the microscope, it is found that stasis is produced which is co-extensive with the surface of contact. It is tolerably certain that in like manner, in

[1 Wagner's Manual of General Pathology.]

vesication of the skin by heat, the circulation of the heated part is abruptly brought to a standstill. As, outside of the area of stagnation, it goes on at first with unabated then with increased vigor, while the walls of the capillaries are probably acted upon by the heat in such a manner as to render them more permeable, we can readily understand how it happens that liquor sanguinis is exuded more rapidly and more abundantly than in ordinary inflammations. From the researches of Dr. Samuel, of Königsberg, it seems probable that the effects of liquid vesicants agree with those of heat in all the respects which have been referred to; so that the peculiarity of the mode of action of vesicant agents in general, would seem to lie in its suddenness and in the faculty which they possess of at once producing those changes in the capillary wall which in ordinary inflammation require a longer time and a more gradual process for their production. In this way the exudation of liquor sanguinis, instead of being deferred until the slowing of the circulation has commenced, begins immediately, and, favored by the primary arterial afflux, and the increased intra-vascular pressure consequent on the sudden capillary obstruction, is so abundant that the liquid collects in blisters.

Relation between inflammation and the reparative process.—When the local injury is so intense as to destroy the vitality of the affected part at once, that part becomes surrounded with a zone of inflamed tissue from which it eventually separates, leaving behind it a granulating surface. To understand this process of demarkation and separation, it is in the first place to be borne in mind that the exuded liquid contains the fibrine-producing elements of the blood, and that contact with dead substance at once determines coagulation of all such fibrinogenous liquids. Accordingly, the first step in the process of reparative separation is the formation, in contact with the dead part, of a more or less solid stratum of fibrine, in which stratum the production of new capillaries and granulation-tissue commences.

What is this granulation-tissue? It consists entirely of young cells, which if they agree with leucocytes more or less in size, differ from them both in structure and arrangement. The neoplastic granulation- or embryonal-cell (as it is often termed) is a mass of protoplasm with a round or oval well-defined central nucleus. It exhibits very slight amœboid movements, and has a marked tendency to endogenous multiplication by division of its nucleus—a process which goes on with such activity that in carefully prepared sections of young granulations it may be studied in all its stages under the microscope with great facility. The arrangement of granulation-cells is determined by that of the newly-formed capillary vessels around which they are grouped. At first irregular, it becomes more and more definite as the new growth is transformed into cicatrix, or into that adenoid texture which is the material of chronic inflammatory induration. It is scarcely necessary to add that the process we have been describing and that of healing by the first intention are essentially the same.

Suppuration.—Before endeavoring to explain how it is that leucocytes, after escaping from the vessels, tend to collect together in groups so as to form foci of suppuration, *i. e.*, abscesses, I would refer to two of the vital endowments which they possess when in the active, that is amœboid state, as perhaps having an important bearing on the question: viz., the power of surrounding concrete matter with which they come into contact with their own substance, and secondly that unexplained tendency which they possess to escape from the blood-current, and to move away from it in a direction at right angles to the axis of the vessel from which they have escaped.

When a bit of fresh cellular tissue is inserted under the skin of a living animal, and allowed to remain there for several days, it becomes soaked with a liquid teeming with living amœboid leucocytes, all of which possess the ingestive faculty just referred to. It has not as yet been experimentally demonstrated that these leucocytes actually prey upon the nutritive constituents of the slough, but it certainly appears as if they determined its liquefaction.

Again, when an abscess is produced by embedding a thread steeped in an irritant liquid in some tissue, leucocytes collect in numbers around the foreign body which soon floats loose in a collection of pus. As the cavity is considerably larger than the irritant, there must have been destruction of the natural tissue. It is surrounded by a zone of reproductive inflammation (pyogenic membrane), in which the neoplastic process already described is going on in full vigor.

In both of these instances the abundant genesis of leucocytes at and around the lesion, which gives rise to the formation of a suppurative focus, manifests itself in absorption or liquefaction of the original tissue. The two conditions stand to each other in a relation so close that we may venture to infer that the latter is a consequence of the former.

The growth of an abscess once formed is explicable on the same grounds as migration in general. Whatever cause determines the rapid filling of a bladder full of liquid inserted under the skin (p. 60),

will also account for their accumulation in the cavity of an abscess, independently of any special action of its lining. With reference to this point, however, there is much probability in the supposition that the newly-formed and dilated vessels of the so-called pyogenic membrane, favor by their structure and arrangement the extrusion of leucocytes.

Why one inflammation is suppurative and another not, is a question we are unable to answer excepting in so far as an answer is contained in the statement that on the whole those inflammations which are most intense and concentrated, provided that the injury done falls short of the production of instant stasis or necrosis, are most suppurative. In other words, so long as blood freely circulates, the quantity of pus produced in an injured part varies according to the intensity of the lesion.

The existence in leucocytes of a power of absorbing tissues with which they are brought into contact is probably the explanation of the destructive tendency which is so important a character of all intense inflammations.[1] The absorption and liquefaction of all the original texture is as peculiar to and inseparable from the process of inflammation as the germinative changes which we have been describing. That it is analogous to ordinary absorption cannot as yet be stated, for we do not yet know whether the wandering leucocytes which are found in healthy connective tissues have to do with that process or not. The only other kind of liquefaction which it could be compared with is the putrefactive, but with this it has not the slightest analogy. For in no single particular, excepting that both result in disintegration, do they resemble each other. Suppurating tissues, so long as they are protected from the influence of external media, do not show the slightest tendency to septic decomposition.

IV. DIRECT INFLUENCE OF ABUNDANT SUPPLY AND FREQUENT CHANGE OF NUTRITIVE LIQUID IN STIMULATING CELL LIFE.

It is well known that if a portion of living structure is removed from its natural position and inserted or engrafted into some other part of the same or of another animal, in such a manner as to be in complete contact with living vascular tissue, the ordinary nutritive changes may go on in the engrafted fragment independently of the direct influence of the nervous system. Hence it may be inferred that if an adequate supply of normal nutritive fluid is the only condition which is necessary to determine the continuance of the ordinary nutritive changes, it is by no means improbable that the modification of this process which goes on in inflammation, may be determined in a corresponding manner by subjecting the tissue to the action of such a fluid as is discharged from congested vessels. With some such considerations as these in view, Stricker[1] devised an experiment consisting essentially in the insertion of a fragment of living tissue into a cavity of which the walls are in a state of active inflammation. A somewhat similar experiment had already been made by v. Recklinghausen in 1863. He introduced the cornea of a frog, immediately after excising it, into a lymph-sac of the same animal, and observed that if the cornea were left in this situation long enough for the cavity to inflame and suppurate, the marginal part of it became charged with leucocytes, which, by virtue of their amœboid movement, penetrated in vast numbers into its tissue. But as v. Recklinghausen had not inserted his healthy cornea into a cavity already inflamed, and moreover had not observed the structural changes which took place, his experiment was not available for the solution of the question. The method adopted by Stricker is as follows: He irritates one eye of a frog by cauterizing the cornea through, then excises the cornea of the opposite eye, and inserts it beneath the *membrana nictitans* of the irritated eye, finally uniting the edge of that membrane with the opposite margin of the cutis by ligatures. After twenty-four hours the transplanted cornea is removed and examined, and is found to exhibit inflammatory changes, which although they are on the whole less advanced than those found in an unexcised cornea, at the same period after irritation, are equally characteristic. In different experiments there were differences both in the degree in which the cornea-corpuscles were altered, and still more in the number of pus-corpuscles, but in all the appearances corresponded with the description which has been already given of the effects of direct irritation.

These results scarcely admit of misinterpretation; they are, however, rendered much more decisive and satisfactory by varying the conditions of experiment in such a way as to show that the changes observed are not due to the penetration of leucocytes from the liquid in which the cornea is immersed, and

[1] On this subject see p. 66.

[1] Stricker, "Ueber die Beziehungen von Gefässen und Nerven zu dem Entzündungsprocesse," loc. cit. p. 31.

secondly that they are not a mere result of its transplantation into an unnatural position. The first of these objects is readily attained by dividing the cornea immediately after excision, plunging one-half in water so as to kill it instantly, and then placing the dead and the living portion together, underneath the *membrana nictitans* of the opposite eye. It is then found that whereas the same inflammatory changes as before go on in the living half, the other half remains inactive. The second result is attained by the observation of what happens when, instead of first cauterizing the eye which is destined to be the recipient of the transplanted cornea, it is left uninjured. At the end of twenty-four hours the cornea-corpuscles are found quite unaltered, and so distinct that the plan is strongly recommended as a method of demonstrating their normal characters.

These varied results seem therefore to show, beyond the possibility of dispute, that the structural changes in the cornea of the frog cannot be dependent either on any influence exercised by the nervous system, or by transmission of the irritative effect from one structural element to another, so that we have good ground for concluding with Professor Stricker that they result exclusively from the stimulating influence of the exuded liquid. The precise physical or chemical conditions are as yet unknown, and are at the present moment subjects of further investigations.

CONCLUSIONS.

1. In every inflammation which attains its full development the changes which manifest themselves in the inflamed part are of three kinds, distinguished from each other according to the organs which are concerned in their production. They are either (1) effects of disorder of the vascular nerves and centre; (2) effects of alteration of the properties of the living walls of the capillaries; or (3) effects of the stimulation of the living cells by transudation of liquor sanguinis.

2. Of these three orders of phenomena the second only can be regarded as absolutely essential to the existence of inflammation, which may, therefore, in the strictest sense, be said to have its seat in and about the veins and capillaries, it being there that the earliest and most constant effects of irritation or injury manifest themselves.

3. The nervous and vascular effects of local irritation cannot be directly described as successive stages of one process; for the determination of blood to the seat of injury which is the sole result, and, if I may so speak, purpose of the vasomotor disturbance, has no relation to the local vascular changes, excepting in so far as it tends to make the exudation more abundant. Exudation of liquor sanguinis, although favored by increased arterial afflux, may occur without it, and as a rule continues after the afflux has ceased. The vascular and textural changes, on the contrary, may be regarded as successive stages of one process, for they are connected by a causal relation—the exudation of liquor sanguinis, in which the former ends, being the determining cause of the latter.

4. The mode in which an injury changes the living substance of the vascular walls so as to make them permeable to the blood is unknown. The nature of the change itself is also unknown, the only clue which we have to its character being that afforded by the structural alterations to which it leads in certain organs, and particularly by those which are observed when the process of reparation, attended with the formation of new capillaries, is commencing. (See pp. 50 and 61.) From these appearances we are led to infer that the primary change consists in the transition of the material from the formed to the plastic condition; from a state in which it is resistant, because inactive, to one in which it is more living and therefore more labile.

5. In all living tissues the effect of inflammation manifests itself in a modification of the action and properties of individual cells. In cells which form part of permanent structures the protoplasm increases in quantity and becomes more or less contractile. Subsequently, it is converted entirely or partly into young cells, either by cleavage or by endogenous germination.

The destructive effects of inflammation are traced with a master's hand in the following paragraphs, reprinted from the article on the same subject which appeared in the former edition of this work. After pointing out that both for pathology and practice it is needful that the student recognize the reality of destructive changes as an essential part of inflammation, Mr. Simon continues:—

"Let him examine inflamed muscle, as, for instance, in the post-mortem examination of a compound fracture or of a recently made stump: He will find the structure weakened, so that it easily gives way with pressure or traction; he will see, under the microscope, that the substance tends to fall into irregular fragments; that its natural striation is more or less replaced, first by an almost homogeneous appearance, and afterwards by an appearance of aggregated granules;

that, with these granules of albuminous matter into which the muscle has resolved itself, there is mixed, even from an early date in the inflammation, a noticeable quantity of minute oil-drops; that often these oil-drops appear before the disintegration of muscle has made much progress, and then arrange themselves in such mutual relation, transverse or longitudinal, as to suggest that the sarcous elements have changed themselves, particle by particle, into oil; that little by little the oil-drops multiply to such an extent as to be the chief visible objects—the limitary membrane of a fasciculus seeming now to be almost filled with finely-divided oil, diffused through some scanty connective albuminous material; that the limitary membrane, within which the muscular material is thus emulsionised, tends also itself to undergo dissolution, and let its proceeds confuse themselves with the similar débris of neighboring fasciculi, till more or less bulk of muscle is reduced to a state of oleo-albuminous liquidity.

"And from this point, if the observer have opportunity of watching the changes which lead to convalescence, he will see that gradually the liquefied material diminishes in volume; that, in proportion as it vanishes, the adjoining parts adapt themselves to the altered relation; that eventually only a scar-like puckering of substance—a kind of tendinous intersection—remains to mark the place where muscular material has irrecoverably melted away.

"Let him examine inflamed bone, as, for instance, in a carious vertebra: He will see that the structure breaks down under his finger, and offers scarcely any resistance to a knife; that the microscopical texture is rarefied—cancelli, canals, lacunæ, being all larger than natural, and the solid framework all scantier; that the material is tending to break into its component parts, and to undergo changes which admit of its being removed by the circulation. In many cases (for example, under the irritant pressure of an aneurism) he will find that a quantity of bone has thus gone, leaving no trace behind—gone of course, only after having first become liquid; and it appears that, when bone is inflamed, the first step towards this disintegration consists in a breach of the ordinary union between the mineral and cartilaginous constituents, with a primary removal of the former, and a chemical change of the latter. If there be discharge from the inflamed part, there will be found in it bits of bone, chemically and microscopically demonstrable.

"Let him examine inflamed nerve, as, for instance, near to where it has been cut in amputation: He will find, says Dr. Lent, the medullary cylinder of each nerve tubule falling, as it were by cross-cuts, into irregular pieces—at first large, but as the process advances, getting smaller and rounder, and assuming the character of oil; till at last the tube-membrane is filled with oily material, which gradually undergoes removal.

"Let him examine the hard textures of an acutely suppurating joint: He will find the strongest ligaments in course of being reduced to an incoherent state—either actually pulpy and half-liquefied and in course of removal, or ready to break with the least traction; he will find (unless proper splintage have been used to prevent it) that dislocation is occurring from this cause; he will find, if the inflammation have been primarily synovial, that the cartilage is smoothly melting away at its surface into the fluid which bathes it, or, if the disease have begun subarticularly, that the cartilage, where subjacent to carious bone, is irregularly eroded and perforated; and throughout, with the microscope, he will find, wherever there are evidences of advancing disintegration, that the softening material is abundantly marked with oil-drops.

"Let him—not in post-mortem examinations, for which there are no opportunities, but during life—observe the results of inflammation of the sclerotic, and ask himself why it is that staphyloma so often follows this disease. He will infer that here, as with other cases which we have considered, the inflammation must have so disorganized the texture, and so enfeebled its normal rigidity, that it can no longer give sufficient resistance to pressure from within, or save itself from being bulged by what now becomes an almost dropsical excess of fluid secretion within the globe.

"Above all, let him examine the products of inflammation furnished by mucous and serous membranes, and by glands: the expectorations of bronchitis, the hawkings of common throat-catarrh, the urine of scarlatina, the acute effusion of serous cavities, and, after death, the inflamed organs themselves. Let him once thoroughly recognize the destructive acts of inflammation, as illustrated in the simple cells of gland or epitheliated membrane; and the whole of this argument will be compendiously before him. He will find cells (especially where they are squamous) shed as dead material, without their first undergoing any appreciable alteration. He will find all others undergoing change in a more or less marked degree—change, of which the essence consists in a loosening and eventually a disintegration of texture, with increased imbibability by fluid, and

graduál accumulation of oil; so that the cell, while undissolved, appears of larger than natural size, its wall less defined, its nucleus dimmer, its contents more granular and oily than in health. Sometimes a cell is thus converted into a mere heap of oil-drops held together by little intervening or surrounding material; sometimes there will be more albuminous matter, perhaps in a granulated or dotty form; sometimes there will be more evident fluidity of contents; but in any case the cell, if retained within the body, tends to break up and contribute with its neighbors to the making of an oleo-albuminous fluid, in which there exist but scanty and evanescent remains of the original cell structure."

J. Burdon-Sanderson.

B. THE SYMPTOMS OF INFLAMMATION.

That inflammation is denoted by "redness and swelling with heat and pain," was the teaching of Celsus some eighteen centuries ago. Subject to a somewhat more free interpretation than perhaps he would have given to his words, the statement may still be accepted as true. And there can be no more convenient way of discussing the symptoms of inflammation than to analyze that celebrated formula; remembering, of course, that it purports to describe only what is common to all inflammation, and that such symptoms as are special to particular inflamed organs will remain for subsequent study.

In all red-blooded creatures REDNESS necessarily accompanies inflammation; redness, seen during life, if the inflamed part be one which we inspect from without, but, at any rate, redness which the anatomist can discover in the dead body. And the redness here meant is not a fixed blot of color, but a redness which during life vanishes when the part is pressed upon, and almost instantly returns when this pressure is removed. It is the expression of that hyperæmia which excitement of texture invariably produces. The part is over-colored, because it is over-full of blood. The ministerial blood-vessels, relaxing their muscular tone, have admitted into their canals more than the ordinary flow of contents; and wherever there is stasis in the capillaries, the coloring elements of this blood are clustered with comparative concentration. Also in many cases, as inflammation proceeds, new bloodvessels develop themselves, and, like the old ones, become filled with blood.

Accidentally, in many inflammations, there will be added to these necessary sources of increased redness the further coloring of hemorrhage; for often the distended and softened capillaries break with the impulse of the circulation, and let more or less blood extravasate itself into the inflamed part. Such spots of hemorrhage, if they admit of being observed during life, can be distinguished from the redness which is essential to inflammation by the fact, that, while the latter disappears under the pressure of the finger, the hemorrhagic spots remain stationary.

The redness of inflammation varies in degree and in tint. The intensity of red represents the quantity of blood which is in the part. The quality of red, on the other hand, represents the rate of the local circulation. The tint shades from scarlet to purple, in proportion as the blood, moving more slowly through the part, acquires a more venous complexion; and the quality of redness is therefore notably a sign of the quality of the local process, the more active inflammation having the brighter red, the more chronic inflammation tending to dark and livid.

Redness due to vascular fulness must accompany inflammation. But it is not in itself a sufficient sign of inflammation; for such redness may be the result of venous obstruction—as we see in the suffused tumid face of a person suffering from dyspnœa. Nor, even when due to arterial expansion, is it necessarily the evidence of inflammation; for every hypertrophic process suffices, like inflammation, to determine an increased supply of blood to the part; and the redness of active hyperæmia is, for instance, as well marked in the uterus during gestation as it would be if the uterus were inflamed.

Generally speaking, the local maximum of redness is conterminous with the local maximum of textural excitement; where there is most of the inflammation, there is most of the redness. But there are cases where this cannot be. With what are called extravascular tissues—tissues which, like cornea and cartilage, are not naturally permeated by bloodvessels, but are nourished by (comparatively speaking) long reaches of imbibition from their ministerial bloodvessels—the maximum of redness will be where these bloodvessels have their capillary plexus. Thus, when the cornea is wounded at its centre and begins to inflame at the injured spot, it is not there, but in the surrounding conjunctiva, that we look for the redness which attends inflammation: for here is the medium through which the cornea in health depends on the circulatory system; and here consequently it is that, when the cornea is inflamed, those vascular changes occur which minister to the act of inflammation.

Swelling in inflammation results partly from the greater abundance of blood which is in the vessels of the inflamed tissue. But mainly it results from the excess of exudation with which the texture is infiltrated, and from the profusion of growth to which that exudation ministers. Obviously then the symptom must vary according to the degree in which an inflamed texture holds this exudation within its substance. In cases of synovial and serous inflammation, the effusion which collects within the shut sac represents what in solid organs would be swelling from infiltration; and where mucous membranes are inflamed, the altered secretion which falls from their surface is, in the same sense, equivalent to swelling. Yet even in these cases (sometimes with the naked eye, sometimes with the microscope) we can recognize that the inflamed texture is not altogether free from true swelling, but presents an amplification of at least its epithelial layer—the interference with respiration which belongs to the beginning of acute bronchitis, the filling up of the kidney-tubules with modified cell-growth in scarlet fever, and the diminished stream of urine during the severity of gonorrhœa, being in this respect illustrations of common inflammatory swelling. Not unfrequently in such cases tumefaction extends to the subjacent areolar tissue; acute ophthalmia may thus occasion the peculiar swelling which is called chemosis; and submucous inflammatory swelling is the cause of those ordinary urethral strictures which often remain from gonorrhœa. It needs hardly be said that, with rigid organs, there may be interior effusion which does not show itself outwardly; the crown of a tooth does not swell when its contained pulp is infiltrated, nor is a bone mechanically bulged out by the swelling of its medullary membrane. Likewise it is obvious that, in loose-textured organs, exterior enlargement will be preceded by a certain amount of solidification of the texture; thus, the state of a lung hepatized by pneumonia (like that, already mentioned, of the scarlatinal kidney) is pathologically equivalent to a state of swelling.

The subject of swelling as a symptom of inflammation would not be sufficiently discussed unless particular consideration were given to the "effusion" which so often is its main ingredient. Every surgical student must have noticed how apt is an inflamed part to be more than commonly juicy. He has seen synovial and serous sacs, when inflamed, fill themselves with pale fluid. He has seen such fluid as the contents of a blister. He has seen it as the main element of swelling in parts which become "œdematous" with inflammation. He has seen it drain away, after hemorrhage has ceased, from the cuts or punctures made into inflamed cellular membrane—as, for instance, in erysipelas. He has seen the dressings of a stump, within the first two days from amputation, soaked through and through with the same sort of drainage. He has seen an inflamed mucous membrane—that of the bowels during cholera, or that of the eyes and nose during common cold in the head—overflow with the same liquidity of product. And even among the ordinary phenomena of suppuration (though here, it may seem, there are more complex conditions to be spoken of) the fact of fluid discharge stands out as the broad characteristic.

What, then, is the meaning of this greater juiciness of an inflamed part? It is an exaggeration of that natural moistening of the tissues which is necessary for their nourishment: an exaggeration in respect of quantity, and also (if the phrase may be allowed) an exaggeration in respect of quality.

The fluid which naturally sweats through the wall of the capillary bloodvessels, and ministers to the nutrition of texture, is of course[1] in some chemical correspondence with the liquor sanguinis from which it emanates, but differs from the parent fluid in containing very much less dissolved matter. For, as animal membrane is much more transudable by the water of the blood than by its salts, and more transudable by its salts than by its albumen, the quality of the normal transudation is fixed by these physical conditions. It is colorless, transparent, alkaline, and of faintly-saltish taste; it contains no shaped constituents; and its specific gravity is but little above that of water. In cases of venous obstruction, where transudation takes place under more than

[1] This is inference, not observation. For the natural blastema of textures cannot be obtained apart from them in quantity which admits of analysis, and our means of judging what it is are founded, partly on filtration-experiments performed under various circumstances with animal membranes and serum, and partly on observation of cases where the natural exudation has become more abundant under influences of a mechanical kind. Carefully-selected instances of passive dropsy, arranged in a series according to the amount of pressure under which (*cæteris paribus*) the fluid has been effused, are the safest indications towards what, at present, can only be an approximation to knowledge of the normal *transudatum* of the blood. Lehmann (perhaps not wisely) lets much of his doctrine rest on the qualities of the cerebro-spinal fluid, the liquor amnii, and the aqueous humor—fluids which, though they fulfil merely mechanical uses, are not of identical composition.

normal pressure, we find that the fluid, besides increasing in quantity, so as to constitute the well-known phenomenon of passive dropsy, presents certain changes of quality: changes which in proportion as the pressure is great, bring it nearer and nearer to the characters of liquor sanguinis. It gets to contain more and more albumen; it even furnishes a fibrinous coagulum. Still it preserves its essential character—that of containing only elements of the liquor sanguinis, and containing them all in less proportion than that wherewith they are contained in the blood. But in extreme cases the apparatus of transudation becomes destroyed, and filtration gives place to hemorrhage.[1]

The so-called "effusions" of inflammation—whether they be serous or purulent, whether they come from shut sacs or from blisters, or from œdematous cellular membrane, or from abscesses, present the characteristics of a blastema which has transuded under more than normal pressure, or with less than normal resistance. Their specific gravity is high; their proportion of albumen is great; and, where they are not purulent, they commonly give a fibrinous coagulum. Often, too, they contain evidence that capillary bloodvessels have given way—products of hemorrhage being mixed, in greater or less quantity, with the products of increased exudation.

It seems proper to note in this place, though the subject is more fully discussed in the pathological section, that capillary bloodvessels cannot in 1869 any longer be spoken of in quite the same language as in 1860. Their canals are now no longer described as bounded by a passive tissue. They must probably be regarded as having in their walls, besides what common physical properties are there, and besides that power of prolescence and ramification which even long ago was claimed for them, also the contractile power of protoplasm, and further, as associated with that power, a certain peculiar penetrability, which perhaps is elective in its exercise, and at least does not mean ordinary disruption. For the investigations of Prof. Stricker, published in 1865 and 1866, seem to have conclusively shown capillary canals undergoing changes of calibre, both spontaneously and under chemical and electrical stimulation; and in the course of his studies, he repeatedly saw red blood-corpuscles sink into the substance of the unbroken capillary wall, and sometimes remain with half their volume within, and half without, the bloodvessels, just as if the wall were an amœba effecting its impropriation of molecules. And in this sense particular importance must be attached to those experiments of Dr. Prussak's (instigated, I believe, by Prof. Stricker) in which the extroition of red corpuscles was seen proceeding on a large and palpably hemorrhagic scale, as though in imitation of sea-scurvy, in animals whose blood had been artificially overcharged with chloride of sodium. Prof. Cohnheim, too, has shown that a similar "diapedesis" takes place in the frog from within the capillaries of a strangulated limb. It may be observed, however, that, apart from these microscopical observations, the mere progress of physics would have led us to doubt whether the walls of capillary bloodvessels could any longer, in the sense of 1860, be regarded as continuous stable partitions between contained blood-corpuscles and surrounding textures. The immensely suggestive researches of Mr. Graham (published[1] in 1861) on the laws of liquid diffusion, and the subsequent instructive studies and speculations of Dr. Moritz Traube[2] as to the ultimate fabric of cell-membranes, have obliged us to reconsider more strictly than before what it is that we mean, with reference to mere imbibition phenomena, by such words as "homogeneous" or "porous" in anatomy; and as the result of this reconsideration we must now, at least provisionally, refrain from speaking, except in a relative sense, of any "continuity" of tissue. Whether the capillaries possess (as some authors believe) a definite anatomical arrangement of permanent stomata between the respective cell-territories of their walls, is, I believe, yet very uncertain: but permeability to the "atoms" of physicists, permeability to the "molecules" of chemists, and permeability to the "corpuscles" of anatomists, seem to be permeabilities which shade into one another with differences of textural aggregation; and it is certain that homogeneous protoplasm needs not be permanently discontinuous even in order that "corpuscles" shall traverse it. The observations of Drs. Stricker and Prussak can no doubt be reconciled with the doctrine of permanent stomata: but they do not seem, in the present state of our knowledge, to require that doctrine to complete them.

But there are two essential characteristics of inflammatory effusion—characteristics which absolutely distinguish this effusion from that of obstructional dropsies—characteristics which cannot be due to any mechanical influence. In the first

[1] See Dr. Robinson's experiments on the effects of obstructing the renal circulation, Med.-Chir. Trans., vol. xxvi.

[1] Phil. Trans.

[2] Archiv für Anat. (Reichert u. Du Bois-Reymond), 1867.

place, the inflammatory effusion tends to contain certain ingredients in larger proportion than that in which they exist in the blood. In the second place, the inflammatory effusion teems with organic forms.

The great chemical characteristic of inflammatory effusions is their excess of chloride of sodium and of phosphates. Pus (says Prof. Lehmann) contains three times as much chloride of sodium as the serum of the blood; and during pneumonia (as Dr. Beale[1] has shown) the lung is so disproportionately loaded with this salt, that the urine is entirely deprived of it; while as regards the phosphates, Prof. Lehmann states that even the thin bloodless weeping of wounds furnishes a fluid more highly phosphatized than the liquor sanguinis. And the value of these facts, in reference to our present subject, may be inferred from a knowledge of the circumstances under which, apart from inflammation, these ingredients generally abound. "Everywhere, even in the lowest forms of life, where the organism is poor in such salts, everywhere (says Prof. Lehmann) where cells and fibres grow, the phosphates sensibly accumulate. And from the most vitalized textures—from muscle, for instance, where material is most actively renewed—the blood returns greatly more dephosphatized than that which returns from less active organs." So with the other preponderant salt: "for (says Dr. Beale) from the analyses of various observers, it appears that a large quantity of chloride of sodium is present whenever the metamorphosis of tissues depending upon cell-development is going on."

In accordance with these chemical characteristics is the microscopical one which has been mentioned, that inflammatory effusions abound with living organic forms. Not indeed all such effusions equally:—for, on the one hand, pus is so densely corpusculated that it seems under the microscope to consist of little but cells, and has on this account sometimes been figuratively spoken of as mere "unsolid texture;" while on the other hand, in many non-purulent effusions, the water so greatly preponderates that cells are scarcely seen unless searched for. But whether more or less abundant, universally, where there is inflammatory effusion, characteristic cells are to be found—cells of which the pus-cell is the type. The typical form is a globule of about $\frac{1}{3000}$ of an inch in diameter, pellucid, consisting of some semi-fluid albuminous matter, and possessing a compound or simple nucleus, which is best seen when the microscopical specimen is slowly acted on by water, or very diluted acetic acid.

A very remarkable addition to our positive knowledge was made in 1863, when a paper by Prof. v. Recklinghausen in Virchow's Archiv made us aware that pus-cells possess the contractility of amœbæ; in virtue of which endowment they can undergo infinite changes of form, can (as with a kind of will) protrude and again retract processes or pseudopods of their common substance, can thus alternately intussusceive and discharge particles of finely-divided solid matter, and can slowly migrate from spot to spot in the body, certainly in the natural interspaces of texture, if not even actually making ways for themselves. It follows that previous microscopical descriptions of the pus-cell—such descriptions as that which is repeated above from my text of 1860—must now be read with the important qualification that they are descriptions of the pus-cell as dead; and that in fresh-formed pus in its natural state those globular pus-cells represent but one of many phases, and, so far as they are present, express only an accidental repose of the function of amœboid motility. Before v. Recklinghausen's discovery, there had been a few isolated and sterile observations of movements of animal cells: but the publication of his paper virtually opened an important new field of study; and during the last six years we have been made acquainted with a very general, perhaps almost universal, diffusion of amœboid power in the normal textures and corpuscles of the living body. In a purely zoölogical point of view this new knowledge has been of singular interest and suggestiveness in ways which cannot here be spoken of; and its pathological interest, which promises to be equally great, is considered in connection with the process of inflammation.

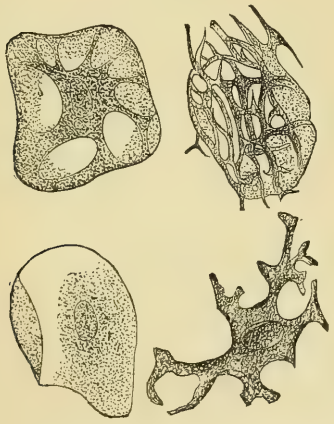
These, then, generally are the changes which characterize the blastema of an inflamed part:—1, it is in most cases demonstrably, in other cases presumably, increased in quantity; 2, it contains far more solid matter, both albuminous and saline, than is normal to it; and besides presenting these features, which may to some extent be attributed to mechanical influences, it 3, gives evidence, by the chemical and microscopical characters which have last been described, that specific chemical affinities are exerted in the part; and 4, it abounds in living organic forms.

Different inflammatory effusions have, however, their special differences. In some there is a great yield of fibrin: it is distinctive, for instance, of the exudation in diphtheria that, by virtue of this quality, it converts the epithelia of the

[1] Med.-Chir. Trans., vol. xxxv.

affected surface into that firm false-membrane from which the disease derives its name; while in some other effusions (and this, generally speaking, is characteristic of well-formed pus) there is no attempt even at partial coagulation. [According to E. Wagner the diphtheritic exudation is a fibrinous metamorphosis of the epithelial cells, and not a fibrinous effusion. The change begins by a general enlargement of the cells, due to an increase of their protoplasm. These are seen to form, first at the periphery, later at the centre of the cell, numerous sharply defined elevations, giving it a porous or indented appearance; finally, the cell, with its prolongations, he compares to the horns of the stag. These prolongations unite with neighboring prolongations of other cells, forming a membrane, but the cells can be again isolated by artificial means. At times the cells appear empty; oftener, however, they contain a nucleus or a pus corpuscle, the origin of which is still a matter of controversy; probably the latter is an emigrated white blood-corpuscle. Besides epithelia thus altered, are always found those which contain either a single pus corpuscle or several, six or more, in a round or oval cavity.

Fig. 17.



Fibrinous degeneration of pavement epithelial cells. High power. (*E. Wagner.*)

Instead of concluding with Wagner, that the metamorphosis of the cells is a fibrinous change, Cornil and Ranvier are disposed to believe that the cells are filled with a material which resembles mucin rather than fibrin. More recent investigations of the histology of the diphtheritic membrane have demonstrated that while the peculiar metamorphosis of the epithelial cells, described by Wagner, does occur, it is only one of the stages of evolution of the false membrane. When the membrane has assumed a yellowish-gray color, or the fourth stage of its development, according to M. Leloir,—the epithelial-cell metamorphosis being the second stage,—the reticulum, formed by the epithelium, is almost completely disintegrated and replaced by exuded inflammatory material, viz., leucocytes and a fibrinous reticulum.] And primary differences of fluidity are noticeable;—compare, for instance, the products of pleurisy or cholera with those of ostitis or muscular rheumatism. Moreover, there are differences (not strictly belonging to the present section of the subject) due to the degree in which the detritus of dead and disintegrating tissues mingles itself with the inflammatory effusion. And, not least, there are differences due to the different degrees in which the effusion itself may have undergone degenerative changes;—for the products of inflammation, shaped and unshaped, cellular and fibrinous, are apt to degenerate by the same sort of process as belongs to the decay of other albuminous material; and in proportion as these degenerations occur, the original characters of the effusion give place to others, among which may particularly be mentioned the presence of oil or cholesterine, and eventually of earthy concretions.

That Pain is a common symptom of inflammation scarcely needs be said or explained. Nerves would be of little use to the body, if they could remain unagitated during a process which essentially involves an unnatural destruction of living tissue. Whenever any bit of the body sloughs, ulcerates, or softens, every included nerve-fibril must share in the common disorganization; and it seems probable[1] that, even in less destructive inflammation, the involved nerve-fibrils undergo such an amount of structural change as fully to account for pain being experienced by the patient. But different inflammations cause widely different amounts of pain; and there are cases, even of very considerable inflammation, where pain is almost absent. These differences of the symptom require some consideration.

Disorganization of nerve-supplied tissue, and stretching or compression of nerve-fibrils, are the two great occasions of inflammatory pain. On both accounts, pain proportions itself rather to the intensity than to the extent of an inflammation; and the most agonizing of all inflammations are those (sometimes of very small extent) where the focus of inflammation is so girt round by unyielding tissue, bone or fascia, that ever so little inflammatory swelling becomes a tight

[1] See Lent, Zeitschrift für wissenschaftliche Zoologie, vol. vii.

compression of nerve. As instances of this, it is enough to cite the extreme pain which attends inflammation of the tooth-pulp or of the tympanum, or generally the great pain which attends inflammation of bone.

Comparatively painless inflammations are chiefly the superficial desquamative inflammations of membranes: in cholera, for instance, the epithelium of the intestine strips itself off almost without pain; and in some kinds of peritonitis, pleurisy, and pericarditis, the serous membrane desquamates, amid a vast exudation from the liquor sanguinis, with almost no pain, and but very slight tenderness. The chief governing condition of these apparent exceptions is, it seems, generally, that the inflammation, measured at any one spot, is not intense, and does not much affect the nerve-containing depths of the texture. Moreover, the cases of serous inflammation where there is no pain are eminently cases where the inflammation arises in conditions not primarily of a simply irritant kind—cases especially, where (as in puerperal fever) morbid poisons are operating on the part; and probably the magnitude of the local product, as compared with the local pain, expresses that the product is less due to mere intensity of the local process than to some changed state of the mass of blood, some state which enables a maximum of exudation to take place with a minimum of textural excitement.

As inflamed parts are not all painful in the same degree, neither are they all painful in the same sort. Indeed the quality of pain differs almost as much as the amount. In those phlegmonoid and tight-bound inflammations where pain is most intense, it especially tends to be pulsatile or throbbing; for every beat of the heart increases that local tension which is the immediate cause of suffering. A sense of extreme local compression—a feeling of being screwed in a vice, is often complained of under these circumstances. In surface-inflammations, the more diffused pain is apt to simulate the impression of fire, or, if less, that of nettles or needles; and the suffering part is said to prick, or tingle or burn. Where ulceration is in progress, the patient's feelings almost represent the fact; for he describes his pain to be that of "something gnawing" at the part.

It is not only by being painful that an inflamed part gives evidence of disordered nerve-action. Over-sensitiveness to exterior impressions is other evidence to the same effect; and this, sometimes in the form of tenderness on contact or pressure, sometimes in forms special to the affected organ, always accompanies pain if the pain be due to inflammation. The fact of its presence or absence is therefore very important, when we would interpret the meaning of any given pain. And further, since tenderness often exists in cases of inflammation where pain is unmarked or absent, it is a sign which, in difficulties of diagnosis, ought always specially to be looked for. Indeed there are many occasions in practice, where the principal business of the clinical investigator is thoroughly to ascertain the existence and the limits of this one symptom; and the surgeon can hardly exercise too much care, when conducting this part of an examination, to exclude all sources of fallacy which depend either on himself or on the patient.

Where mucous membranes are inflamed, their increased sensibility often shows itself by producing increased reflex-motory phenomena. And the muscular actions which thus result become indirectly symptomatic of inflammation; for they testify that the nervous centres which regulate them have received from the mucous surface certain exaggerated representations of contact. Thus it is that common catarrh produces cough, that bronchitis and asthma become associated, that inflammation of the stomach is attended by vomiting, and that during the slight cystitis of severe gonorrhœa the patient's urine is often squirted into his breeches.

Where organs of special sense are inflamed, special sensations are experienced. The patient with deep-reaching inflammation of the eye seems to see sparks or flashes of light; the patient with post-faucial catarrh gets a sense of bitterness in his throat; the patient with inflammation of the internal ear has an impression of unreal sounds. Such signs, where they exist, are of course pathologically equivalent to pain. But as there are these special analogues of pain, so there are special analogues of tenderness; witness the intolerance of light which attends many ophthalmic inflammations, and which is as much a fact of over-sensitiveness as if the eye were painful on pressure.

It remains to be mentioned that pain, as a symptom of inflammation, is often referred to a larger extent of tissue than is actually inflamed, and sometimes to parts not directly continuous with the inflamed one. The pain of a whitlow, at first confined to the immediate vicinity of the nail, where alone the inflammation exists, may presently include the finger, then the rest of the hand, then the forearm, and finally may give uneasiness to the whole extremity as high as the shoulder. The pain of ophthalmic tension is in great part referred to the brow. The pain of hip-disease is often chiefly,

or even entirely referred to the knee. Out of the pain of common toothache, semifacial, semicranial, even semicervical pain may develop itself. Inflammation of the liver commonly produces pain in the right shoulder; the pain of renal inflammation is more or less referred to the bladder; and inflammations of the pelvic viscera cause pain to be felt in the thigh.

HEAT.—It has long been matter of common observation that an inflamed exterior part is hotter than natural. And this increased heat, where it exists, is accepted for a sign of inflammation as much as either pain, redness, or swelling. But hitherto the meaning of the symptom has been much disputed among pathologists.

By some it has been believed, chiefly on the strength of Hunter's experiments, that an inflamed part is passive in the alleged change of temperature; that nothing more can take place in it than a raising of its temperature to that of the blood which supplies it; that, if an exterior part gets warmer when inflamed, this is simply because it is fuller of blood; and that interior parts (since their temperature naturally equals that of aortic blood) cannot be made warmer by inflammation.

Hunter's experiments were such as the following:—

"A man had an operation for the radical cure of the hydrocele performed at St. George's Hospital. When I opened the tunica vaginalis I immediately introduced the ball of the thermometer into it, and close by the side of the testicle. The mercury rose exactly to 92°. The cavity was filled with lint, dipped in salve, that it might be taken out at will. The next day, when inflammation was come on, the dressings were taken out, and the ball of the thermometer introduced as before, when it arose to $98\frac{3}{4}$° exactly. Here was an increase of heat of $6\frac{3}{4}$°; but even this was not equal to that of the blood, probably, at the source of the circulation in the same man. This experiment I have repeated more than once, and with nearly the same event. As the human subject cannot always furnish us with opportunities of ascertaining the fact, and it is often impossible to make experiments when proper cases occur, I was led to make such experiments on animals as appeared to me proper for determining the fact; but in none of them could I ever increase the inflammatory heat so as to make it equal to the natural heat of the blood at its source. I made an incision into the thorax of a dog; the wound was made about the centre of the right side, and the thermometer pushed down, so as to come in contact, or nearly so, with the diaphragm. The degree of heat was 101°; a large dossil of lint was put into the wound to prevent its healing by the first intention, and covered over by a sticking-plaster. The dog was affected with a shivering. The day following the lint was extracted, and the thermometer again introduced; the degree of heat appeared exactly the same, viz., 101°."[1]

Other pathologists have held an opinion different from Hunter's. Partly on theoretical grounds, and partly on the strength of some experiments[2] performed in 1835 by Messrs. Becquerel and Breschet, they have supposed that an inflamed part is actively calorific; that it is, or tends to be, warmer than the blood which supplies it; and that this excess of heat is as much an effect of local action as the formation of pus, or the softening of spoilt tissue.

The French experimenters (using a thermo-electric apparatus with some arrangements devised for them by M. Sorel) attempted to take the absolute temperatures of certain skin-covered parts by needles thrust through the integument. The temperature of the *biceps flexor cubiti* was commonly thus taken as a standard of internal temperatures; and the temperature was also measured in the mouth. In a scrofulous girl, suffering from marked feverishness, the temperatures thus taken, were: in the mouth, C. 37°.50; in the biceps, 37°.25; in an inflamed scrofulous tumor at the lower part of the neck, 40°; in a fungating tumor of the cellular membrane, also 40°. In a woman, æt. thirty, having a similar disease: mouth, 36°.75; biceps, 37°; tumor, 37°.50; adjacent cellular membrane, 35°. In a case of cancer of the breast: mouth, biceps, tumor and certain fungations which were there, all 36°.60. In a young man with scrofulous caries of tarsus: mouth, 36°.50; biceps, 37°.50; wound (the needle going through the plantar fascia) 32°. In a case of typhoid fever with bronchitis: mouth, 39°.65; biceps, 38°.80. I may observe in passing that these observations seem in various respects to contradict one another, and that, even on the assumption of their having been faultlessly made, no definite conclusion can be drawn from them.

With reference to Hunter's view of the case, it may be fully conceded (putting inflammation out of the question) that any exterior part does get warmer in proportion as it is more copiously traversed by blood; witness M. Bernard's discovery, that considerable permanent increase of temperature takes place, without inflammation, in the integument of the head, whenever an experimental division

[1] Hunter's Works, ed. 1837, vol. iii. pp. 338–9.

[2] Comptes rendus de l'Acad. des Sc., tom. i., or Ann. des Sc. Nat.

of the cervical sympathetic has reduced the external carotid artery and its branches to a state of paralytic dilatation which occasions the textures supplied by them to be habitually overdosed with arterial blood. Accordingly, if Hunter's experiments were conclusive as to the fact of an inflamed part not being hotter than the blood which it receives, the explanations founded on those experiments might be satisfactory. On the other hand, if an inflamed part be, as Messrs. Becquerel and Breschet are supposed in some cases to have found, considerably hotter than internal organs of the body (which in effect would mean considerably hotter than the blood which it receives), then, we need hardly say, Hunter's explanation would be valueless.

Everything therefore turns on facts of comparative thermometry. And the solution is not easily to be obtained. For to learn by experiment, either generally whether textures are hotter than the blood which supplies them, or specially whether inflamed textures are paramount sources of heat, is a matter of infinite nicety. The passage of blood through a part incessantly tends to equalize its temperature with that of other organs; and unless the local production of heat were really great, all traces of difference would be thus swept away in successive waves of the circulation. Therefore not only is it the case that the finest differences of temperature have to be accurately observed, but every alleged great excess of local temperature must at first be accepted with mistrust. It is not too much to affirm, that the opposed sets of experiments hitherto referred to are entirely inconclusive on the subject. In neither one set nor the other was there any attempt to deal with what would now be recognized as the difficulties of the inquiry. Hunter's observations were, in this instance, evidently coarse and imperfect; the rival thermo-electric observations, though purporting to be more exact than his, are perhaps even less trustworthy;[1] and the alternative therefore still lies before us for decision—"Is heat a symptom of inflammation only in external parts, and only as a passive result of their over-fulness with blood? or is the inflamed part actively productive of heat?"

For settling this uncertainty, the writer believes that some thermo-electric observations which he, with the valuable aid of his colleague Dr. Edmund Montgomery,[1] has recently made on the subject, may be deemed practically conclusive. And on the evidence of these experiments, he now ventures to say that an inflamed part is no mere passive recipient of heat, but is itself actively calorific.

A miniature thermo-electric battery was made by the angular contact of platinum and iron; each in a single delicate bar, which, where soldered to the other, was brought to such sharpness that the end of the metallic commissure could be thrust, like a pin, into any soft animal texture. Two such thermo-electric pins or batteries, connected by copper wires with one another and with a sensitive nearly astatic galvanometer, were used as means for comparing the relative temperatures of media with which they respectively were brought into contact, and were found quite sufficient for the purpose: for when one of them was made ever so little warmer than the other, the fact was instantly indicated by a corresponding movement of the galvano-metric needle. With this preface, the annexed tabular statement of experiments will sufficiently explain itself. (See next page.) A preliminary experiment, corresponding to those numbered 1, 7, and 9 in the table, was performed May 21, 1860, and showed (as in Nos. 1, 7, and 9) the higher temperature of blood returning from an inflamed part. The experiments here described were all performed May 24th. It will be observed that only *relative* temperature is measured; but also it is only with relative temperature that the argument at present is concerned; and it would have been no easy task, with existing thermometric appliances, to obtain the absolute temperatures for comparison, or even to translate the present comparisons into exact numerical expressions.

The conclusions which these experiments justify are as follows: first (Exp. 3, 5, 8, 11), that the *arterial blood* supplied to an inflamed limb is less warm than the focus of inflammation itself; secondly (Exp. 2, 4, 10), that the *venous blood* returning from an inflamed limb, though (Exp. 6) less warm than the focus of inflammation, is warmer than the arterial blood supplied to the limb; and, thirdly (Exp. 1, 7, 9), that the venous blood returning from an *inflamed limb* is warmer than the corresponding current on the opposite side of the body.

Unquestionably, therefore, the inflam-

[1] In the judgment of perhaps the first biophysicists of Europe, Helmholtz and Ludwig, the experiments of Becquerel and Breschet are of little value. Helmholtz (Müller's Archiv, 1848, p. 145) speaks of them as observations "gegen deren Richtigkeit viele Einwürfe erhoben werden können;" and Ludwig (Physiologie, edit. 1858, vol. i. p. 468) refers to the method of investigation as being "mit zu vielen Fehlern behaftet, als dass die durch sie gewonnenen Resultate werthvoll wären."

[1] The entire merit of the apparatus described in the text belongs to Dr. Edmund Montgomery, who devised and arranged it for the writer.

TABLE SHOWING COMPARATIVE TEMPERATURE OF INFLAMED AND UNINFLAMED PARTS.

Subject of observation, and nature and date of injury which had caused inflammation.	Places of insertion of the thermo-electric pins.		Deflexion of needle, indicating the side of higher temperature.	No. for reference.
	Pin connected with the western half of the galvano-multiplier.	Pin connected with the eastern half of the galvano-multiplier.		
A dog with severe compound fracture of the right leg, inflicted about 72 hours previously; since when his general temperature had risen from 38.2° to 39.5° C.	in femoral vein of inflamed limb	in opposite femoral vein	Westward	1
	in femoral vein of inflamed limb	in opposite femoral artery	Westward	2
	in femoral artery of inflamed limb	in inflamed part	Eastward	3
A second dog with severe compound fracture of the right leg, inflicted about 48 hours previously; since when his general temperature had risen from 38.1° to 39.3° C.	in femoral artery of inflamed limb	in femoral vein of inflamed limb	Eastward	4
	in femoral artery of inflamed limb	in inflamed part	Eastward	5
	in femoral vein of inflamed limb	in inflamed part	Eastward	6
	in femoral vein of inflamed limb	in opposite femoral vein	Westward	7
	in abdominal aorta	in inflamed part	Eastward	8
A third dog with severe compound fracture of left leg, inflicted about 19 hours previously; since when his general temperature had risen from 37.6° to 38.9° C.	in femoral vein of healthy (right) limb	in femoral vein of inflamed (left) limb	Eastward	9
	in femoral artery of healthy (right) limb	in femoral vein of inflamed (left) limb	Eastward	10
	in inflamed part	in femoral artery of inflamed limb	Westward	11
For Standard	untouched in atmosphere of room	between finger and thumb of experimenter	Eastward	12
	between finger and thumb of experimenter	untouched in atmosphere of room	Westward	

matory process involves a local production of heat. Doubtless it is an essential connection, and according to what seems the general and normal correlation of heat and life, that an increased evolution of heat accompanies the increased vital effort, the increased textural changes, of inflammation. And let it also be noted, as a fact of which the importance will presently appear, that an inflaming part, in proportion to its heated venous outflow, necessarily raises the temperature of the common mass of circulating blood; that thus the local disorder represents an influence which tends to diffusion throughout the body. [These experiments of ascertaining the temperature of the blood during inflammation, by means of thermo-electric observations, have been repeated by several investigators. O. Weber from his experiments came to the same conclusions as Simon. Jacobson and Bernhardt found that without exception, the temperature of the inflamed parts was less than that of the heart. Landieu from numerous observations found that the temperature of the skin or muscles inflamed to a high degree, never reaches that of the interior of the body. But the temperature of an inflamed part, in the acute stage, usually exceeds that of the corresponding healthy part. He also found that the arterial blood (femoral artery in dogs), was higher than that of the focus of inflammation which it supplied.]

Reviewing, then, the four classical symptoms — pain, redness, heat, and swelling—we find that in every examinable case of inflammation, they, or signs equivalent to them, may be locally discovered;—if not always pain, at least always *increased sensibility;* if not always redness of the inflamed part, at least always *increased afflux of blood towards it;* if not always swelling, at least always *increased quantity of matter;* and finally, under all circumstances *increased heat.*

Other local symptoms may be added to these. For, first, something *complicative* may come to them by mere accident of position. Where the walls of a visceral cavity are affected, the contained organs, originally free from disease, may be injuriously pressed upon or denuded. Where the neighborhood of a canal is inflamed, the canal may be encroached upon by swelling. Where large bloodvessels are concerned, ulceration may be dangerous by hemorrhage. And so forth.

And further, an inflamed part often gives rise to special symptoms of its own; for its function is interfered with by the disease, and signs of this *functional disturbance* are added to the common symptoms of inflammation. Thus, if the kidneys be inflamed, the urine will be altered in quality, will more or less tend to represent a mere filtration from the blood, or perhaps will be entirely suppressed; and, secondarily, there will arise the consequences of that general blood-poisoning which ensues whenever urine is imperfectly discharged from the system. Thus again, if the lungs be extensively inflamed, due aëration of the blood becomes impossible; and, while the patient is tending to die by suffocation, chemical analysis may show that waste carbon, which his lungs cannot oxidize and discharge, is passing by other channels from the body.[1] In these, and in almost all cases of inflammation, the nature of the functional disturbance is, that the function is more or less suppressed. To some extent this comes mechanically, and is, so to speak, an accidental complication of inflammatory swelling in the part. But greatly also, at least in most cases, it has to do with another influence, and implies for function what disorganization implies for structure—Death. And just as, amid the structural disorganization of inflamed parts, we recognize traces of mere hypertrophy wherewith the process (if gradual) commenced; similarly, were our knowledge of function more complete, we should probably find that, so far as functional disturbance in inflammation is not of mechanical origin, thus far it also begins with mere over-performance of natural acts, and thus far the eventual suppression of function denotes *exhaustion subsequent to excitement.* It is only with respect to the nervous system that observation can here be appealed to; but the relations of cramp to paralysis, of delirium to coma, and of madness to dementia, may be quoted as of the kind in question.

It remains to be stated that inflammation has, besides its local symptoms, another essential characteristic. In proportion as any considerable part of the body becomes acutely inflamed, the patient's blood (if not affected by perturbing causes) invariably rises in temperature, and herewith the patient complains of what is commonly called *feverishness.* Taking, for instance, a case of severe compound fracture, without much hemorrhage, in a person otherwise sound and strong, we find that, before twenty-four hours have elapsed from the time of injury, his general system begins to be thus affected. He feels hot, or alternately very hot and chilly. His skin and lips and mouth are dry. He passes urine in less quantity, but of higher color, than usual. His pulse is quickened. A sense of general disorder gains upon him. He becomes restless and intolerant of disturbance. Signs of drought increase with him. His urine becomes scantier and more colored. His skin feels hotter to the surgeon's hand, and his pulse, whether full or hard, is quicker and stronger than before. He craves more and more for water. His face has a flushed anxious look. He is thoroughly uncomfortable; for the most part feeling distressingly hot, but at irregular intervals feeling touches of chilliness—sometimes even of such cold that he shivers with it. His sleep is troubled and unrefreshing; or, as night comes, he gets delirious. His tongue, besides being dry, is furred. If his bowels act (which commonly they are unapt to do without laxatives) the excretions are morbidly offensive. Gradually these symptoms give way; in proportion as the injured limb ceases to be tense, and passes into suppuration, the skin and mouth become moist again; the excretions lose their concentrated character; the hard pulse softens, and the heart's action becomes quiet; the nervous system is no longer restless; the look of trouble passes from the countenance; and the patient can again take solid food.

The constitutional affection which thus runs its course in sympathy with the local inflammation is commonly known by the name of "inflammatory fever." The description just given of its symptoms purports only to represent the chief

[1] See Beale, op. cit. p. 354; where an instance is given of melituria thus dependent on pneumonia.

facts of a typical and uncomplicated case. But practically the affection shows numberless grades and differences and complications.

First there are wide differences of degree and duration: for, in proportion as the local process is less acute and less extensive, there is less attendant febrility; and in proportion as the local process has to invade fewer successive strata of texture, the fever is of shorter course. On the one hand, it may be so slight as readily to escape notice, and may end within a few hours of its commencement; on the other hand, it may last in full force during many successive days, and may be so severe as to shake the patient's life to its foundation.

And besides these differences, there are varieties of result—sometimes from complicative local conditions, sometimes from peculiar susceptibilities of the patient. If the wound become the seat of some large textural disorganization, with consequent soakage of putrefying material, signs of blood-pollution may be expected to mix with or supersede those of common inflammatory fever; the patient's general state will then incline to be one of depression and apathy; his tongue will be more than commonly foul, and fetid diarrhœa will probably exist. Or if perchance during the local process it happen (as is especially apt to be the case where cancellous bone-structure is affected, and generally at a time when common febrile excitement has passed its maximum) that pus passes up a vein into the general stream of blood, the patient's improvement is abruptly cut short by the severe recurrent rigors and sweatings of pyæmia, accompanied by local signs of secondary suppuration in parts to which the pus is conveyed. Further, the quality of the pulse during inflammation, and generally that look of vehemence in the febrile process which depends upon the circulatory system taking an active part in the production of symptoms, will be almost unlimitedly influenced by the more or less vigor of the patient. With weakened nerve-power, with feeble heart-structure, there can be no strong hard pulse; nor can the pulse be otherwise than soft or small, when the bloodvessels are half emptied of their contents. Old age, and every kind of depressing, debilitating, or exhausting influence, must therefore tend to prevent certain symptoms of fever from developing themselves; and the surgeon who wishes rightly to estimate the degree in which his patient's general system is sympathizing with some existing inflammation, must guard himself against these sources of fallacy, by referring in all doubtful cases to what is the one sure measure of fever.

It has already been said that in proportion as any considerable part of the body becomes acutely inflamed, the patient's blood (if not affected by perturbing causes) invariably rises in temperature. This is the essential fact of inflammatory fever. It is to this fact, that the familiar language of feverishness bears witness; the thirst, the scanty urine, the heat and the shivering, the troubled brain, the excited circulation. As the blood gets hotter and hotter, more and more do these symptoms become developed. As the blood subsequently gets cooler, so, more and more, do they decline.[1]

It is necessary to remark that what is here said specially of the symptoms of inflammatory fever, is true generally of the febrile state. Whether we are dealing with the effects of mechanical injury, or with a case of smallpox or pneumonia, the symptoms which in common medical language are called *feverish*, are essentially the signs of heated blood. This in effect is no new doctrine; for even Galen, seventeen centuries ago, when maintaining that fever was but a preternatural bodily heat (*παρὰ φύσιν θερμασία*), disclaimed for himself that he had any originality of opinion, and declared that popular instinct, on the present point, concurred with the teaching of all competent physicians. But it is only of late, only with aid of exact thermometric observations, that the facts have been scientifically established; and hitherto the subject has been much less studied in surgical practice than in connection with infected fevers and visceral inflammations. Especially the connection of those thermometric facts with others of a chemical kind—a connection tending to show that febrile heat is always associated with an increased devitalization and waste of organic material within the body, is even yet but in progress of being demonstrated, and only admits of being stated in very unprecise terms. So far, however, as the subject is yet learnt, the following propositions seem certain.

First. Increased temperature of the blood is (as above stated) an invariable fact in the febrile state, and, according to its degree, measures the intensity of fever.

Second. This statement applies not

[1] The following observations of temperature in common inflammatory fever were made for the writer by Dr. Montgomery during the compilation of the present paper, January, 1860. The cases were all in the wards of St. Thomas's Hospital; the first three under the writer's care, the fourth under that of a colleague. The subject is further illustrated by the observations of general temperature made in connection with the experiments recorded at page 76. (See table, page 79.)

only to the facts of continued, uniform febrility, but equally to those of remittent and intermittent febrility, including ague and hectic.

Third. The feelings of chilliness—even the rigors, which are a conspicuous symptom in many febrile disorders, furnish no exception to the general statement; on the contrary, febrile chilliness probably denotes a more rapid heating of the blood; and febrile rigor, as it occurs in ague and pyæmia, is distinctively the sign of sudden rises of temperature.

Fourth. Febrile excesses of bodily temperature range perhaps to 10° F. above the normal heat of the blood; the "crisis" of a febrile state consists in a rapid and generally continuous reduction, the "lysis" in a slow and generally discontinuous reduction, of this abnormal temperature.

Fifth. The excessive heat of the blood suffices to explain the apparent drought of the body; for the contact of the hotter blood, acting as an universal textural stimulant, and rendering every particle of living texture throughout the body more than commonly absorbent and appropriative of blastema, necessitates (if the blood's ordinary constitution is to be maintained) that a greatly increased supply of water shall be furnished from without, and implies that, till the satiation of this requirement, the excretions shall be comparatively waterless; beyond which it is to be counted that the hotter blood inevitably steams away much more vapor by the

Day of observation.	*Man aged* 29. Amputation above knee for osteosarcoma of the tibia.			*Man aged* 41. Injection of tincture of iodine into the knee-joint for chronic hydrarthrosis.			*Man aged* 36. Small tumor removed from the upper surface of the foot, 44 hours before the first temperature was taken.			*Boy aged* 16. Syme's operation, 46 hours before the first temperature was taken.		
	m n. 10–11	aftern. 3–4	even. 8–9	morn. 9¼–10½	aftern. 3–4	even. 8–9	morn. 10–11	aftern. 4–5	even. 8–9	morn. 9–9¼	noon. 11½–12	aftern. 4–5
I		36.15	36.50		36.55[1]	36.50						
II	36.40	36.50	36.60	36.30	36.50	36.70						
III	36.40	Operation at 2.30	36.75	35.90	Operation at 3.20	37.00[2]	38.20[1]	38.30	38.90		36.60	37.90
IV	38.30	38.30	38.20	37.70[3]	37.70	38.30	38.30[2]	38.30	38.20	37.30	37.80	38.40
V	37.90	38.40	38.30	37.60	37.45[4]	38.20	37.65[3]	38.10	38.10	37.20	37.15	39.40[1]
VI	39.20[1]	37.30	38.05	36.70[5]	36.90	37.20	37.10	37.10	37.20		36.80	38.80
VII	37.70	39.10	38.20	36.35[6]	36.50	36.20	36.70	36.70	37.10	36.40	39.40[2]	38.00
VIII	37.50	38.00	37.80	36.30			36.60	36.70			36.60	37.40
IX	36.85	37.30	37.7								36.30	37.30
X	36.80	37.20								36.20		37.00
XI										36.25		36.45
XII										36.25		36.60

[1] At 7 morn. slight shivering.

[1] Patient keeping his bed.
[2] Pain began after 5 afternoon.
[3] Knee swollen and painful.
[4] Pain also in opposite knee, and in both legs from knees downwards.
[5] Diminution of pain and swelling has begun.
[6] Scarcely any more pain.

[1] Inflammation of the tissue surrounding the wound; foul tongue; sickness; headache.
[2] Inflammation spreading over the upper surface of the foot.
[3] Sloughing of flap of integument.

[1] At 1.30 p m. patient had shivering.
[2] At 11 morning, some shivering.

lung; and further it may possibly be the case, as Dr. Parkes ingeniously suggests,[1] that some intermediate waste products of the febrile body are (like gelatine) extraordinarily attractive of water.

Sixth. Excessive heat of the blood suffices to explain a stimulated state of nervous centres and of organs dependent on them; for (besides what is known of the action of heat on living textures generally) the experiments of Chossat have shown, with special reference to the nervous system, that, when its functions are in the very act of dying by starvation, a mere augmentation of temperature will revive their activity, and gradually bring the subject of experiment into a state from which recovery by nourishment is possible.[1]

Seventh. Excessive heat of the blood suffices to explain the excitement of the heart's action; partly as the result of a more stimulative impression on the endocardium, partly as the result of a more stimulative supply to the cardiac ganglia.

Taking it then for granted that the leading symptoms of fever are accounted for—some of them entirely, others at least in great part, by the fact of the blood's increased temperature, whence, we may now ask, comes this greater heat of the blood? In the present state of physio-

[1] "It is now well known that during endosmosis different organic substances absorb or take very different quantities of water through membranes. For example, the endosmotic equivalent of sugar is a large amount of water, and, in consequence of this physical law, sugar attracts water largely from the blood, and carries it from the system. Hence the unquenchable thirst of diabetes; for every structure is robbed of its water by the powerful attraction of the diabetic sugar. Is it possible that in fever some substance is produced which has as powerful an attraction for water as sugar, and the action of which may cause the universal thirst? A fact mentioned to me by Mr. Graham will put my meaning in a clearer light. Mr. Graham has discovered that gelatine has an extraordinary attraction for water, so that it will even take it from alcohol, and render alcohol almost, if not quite, anhydrous. This property, manifested at all temperatures, is particularly marked at the temperature of 98° to 100° F. Albumen, on the other hand, has little attraction for water, and yields it up at once to alcohol. Now, supposing that, in the rapid metamorphosis of albuminous substances in fever, gelatinous compounds, or something approaching to them, were formed—and this is by no means unlikely—then, as a consequence of a physical law, the gelatine would at once take water from the albuminous tissues, and would necessarily give rise to intense thirst. Then, unlike sugar, the gelatinous substance would not be discharged, but must be converted into urea, and uric acid, as ordinary gelatine is when it is taken as food. I mention this hypothesis merely as an example of how water might be retained in the febrile body. At present, of course, we do not know whether any such compound is or is not formed, for the transition-steps, and they may be numerous, between organized albumen and urea are not yet known." ("Gulstonian Lectures on Pyrexia," in Med. Times and Gazette, vol. x. p. 333.) These Lectures claim a very respectful mention; not only as embodying an admirable statement and criticism of the modern doctrines of fever, but equally as recording many important observations, made by Dr. Parkes himself, with regard to the acts of elimination in fever, and the relation of these acts to the abnormal heat of the blood.

[1] Chossat's 29th experiment (though it did not, like many of the others, go on to the animal's complete restoration) may be quoted as illustrating this argument: "Une tourterelle, dont le poids initial était = 142ᵍ.52, ayant été soumise à une alimentation insuffisante, vers la fin du 6ième jour de cette alimentation se trouva arrivée à l'état de mort imminente, et son poids était réduit à 96ᵍ.66. Dans l'état en question, la station depuis deux heures de temps était devenue impossible: le corps était étendue, la tête pendante; les yeux étaient ouverts, fixes, sans clignotement, et le froissement des orteils n'accusait plus qu'un faible reste de sensibilité aux extrémités postérieures. La respiration, depuis quelques minutes, n'était plus appréciable; le corps froid; la chaleur animale = 23°.0. La perte de poids intégrale proportionelle = 0.350. C'est dans cet état, que j'appelle de *mort imminente*, parce qu'au bout de peu de minutes il devait se terminer par la mort, que j'ai placé l'animal dans l'étuve, et que j'ai commencé le réchauffement. Appelons 0ʰ 0′ le moment du début du réchauffement, et voyons ce qui est arrivé pendant la durée de celui-ci. Après deux minutes (0ʰ 2′), la respiration est devenue très-marquée; 0ʰ 6′, la respiration est bonne; l'animal est plus animé; il remue la tête; 0ʰ 7′, les yeux sont redevenus sensibles, et le clignotement est rétabli; 0ʰ 10, respiration naturelle; la vie revient de plus en plus; 0ʰ 31′, l'animal est bien vivace; il agite ses ailes comme pour se sauver; 0ʰ 34′, la station sur les pattes est redevenue possible; mais elle est encore chancelante, et l'animal ne se soutient qu'en agitant les ailes; tête encore vacillante; 0ʰ 43′, l'animal paraît bien remis. Étant obligé de le quitter, je l'enveloppe d'un tissu qui l'empêche de s'envoler de dessus l'étuve pendant mon absence; 2ʰ 7′, à mon retour, je trouve l'animal mort sur l'étuve, la tête renversée en arrière, dans un état d'opisthotonos. La chaleur dans le cloaque = 48°.7; le poids du corps = 90ᵍ.58, et la perte pendant le réchauffement = 2ᵍ.08. L'animal n'ayant pas pu quitter l'étuve, comme il l'aurait fait, s'il n'y avait pas été emprisonné, il est évident que sa chaleur s'y était élevée progressivement à cinq ou six degrés au dessus de l'état normal, ce qui était plus que suffisant, comme on sait, pour amener la mort par la chaleur."

logical opinion as to the ordinary sources of animal heat, the speculation is instantaneous, that the greater heat of fever must correspond to some greater transformation of organic material. Many excellent observers have set themselves to inquire how far this conjecture is right; and the results of inquiry, so far as they have gone, are to the following effect: that, either continuously during the intensity of feverishness, or else more abruptly and as it were decumulatively when feverishness begins to subside, there can commonly be traced in the excretions an excess, more or less considerable, of those nitrogenous, sulphurized, and phosphorized products which emanate from textural and humoral waste; that this increased elimination is observed even when ingestion has been reduced to a minimum; and that febrile excretions do therefore, as a rule, undoubtedly attest an increased devitalization of bodily material. I do not pretend to discuss what is the intimate physical relation between febrile heat and increased material change. Whether in reference to local inflammation or to general febrility, I can only speak of them as two concurrent groups of phenomena; and instead of pretending to discuss what may be their mutual relations, I take them as essentially conjoint. Viewing them thus together as one complex fact of dynamical excitement (complex in any inflamed texture, and complex in any fevered blood), and confining myself now again to the case of surgical inflammatory fever, I will only attempt to show how it is that this dynamical excitement diffuses itself in the body—how it is that, from being local, it becomes general—how it is that feverishness superadds itself to inflammation.

Without hesitation we may conclude that the process spreads by common material contagion; that the returning fluids of the inflamed part—its venous blood and its lymph—are the agents of general infection. For if a part be developing preternatural heat, and undergoing preternatural change, its venous and lymphatic out-flow must of necessity represent those excesses of heat and change; and this out-flow with all its belongings, material and dynamical, shedding itself without interruption into the blood, must straightway be diffused throughout the body. Not inactively, we may presume; for the blood receiving such increments of heat as the inflamed part thus contributes to its temperature, and receiving also that unwonted afflux of chemically changing material which comes from the disorganizing textures, is doubtless itself stimulated to greater activity of change. And as it circulates throughout the body, so, to every texture which it supplies, there is brought more than common incentive to change; till, in proportion as the fever is great, every texture, according to its chemical mobility, gets to participate in the excitement, reflects as it were in a lesser scale the disorder of the inflamed part, and contributes a share to that over-production of waste-products and of heat which is characteristic of inflammatory fever. The frequency with which, during accidental febrility, some predisposed texture will break out into the gouty or rheumatic inflammation special to itself, is a beautiful illustration of what is here advanced.

It were greatly to be wished that something definite could be said about the microscopical and chemical character of the blood during inflammatory fever. But observations in this field are among the most difficult in pathology; and probably many years must yet elapse before the subject can be adequately discussed.

It has been said by competent observers, that during inflammation there is a notable increase in the proportion of colorless corpuscles in the blood. But our means for measuring the proportion of white to red corpuscles are hitherto so imperfect that different microscopical examinations of the same blood will give the most contradictory results; and the reports hitherto made on the subject in its relation to inflammatory fever are too imperfect and too discordant for general conclusions to be drawn from them.

[The difficulties which have previously prevented anything like accurate conclusions being reached, in regard to the relative proportion of white and red blood-corpuscles during health or disease, have been very materially, if not entirely, removed by the several instruments introduced by different investigators. Theoretically the working of these instruments may be said to be absolutely correct, yet in their employment it is found that there will be some variations in the results obtained. Notwithstanding this fact, we feel justified from our observations, which have been made with all care, and also from our familiarity with the working of the instrument, in offering some conclusions as to the condition of the blood in respect to the increase or decrease of the white corpuscles during inflammation. The investigations were made in connection with the assistance of Dr. Chas. B. Nancrede, whose experience in blood-cell counting has been very extensive. The instrument we employed was the same used by Drs. Henry and Nancrede in their blood-cell-counting observations reported in the Boston Med. and Surg. Journal, 1879.

The several instruments invented by the different experimenters are all con-

structed upon the same principle; they vary only in the readiness of counting the cells, and the method of calculating the percentage as compared with health. The results are obtained by having a definite quantity of blood diluted with a definite quantity of fluid, a portion of which is placed in an accurately measured receptacle, and examined under a microscope provided with an eye-piece micrometer; then the counting is done and the calculation made of the number of corpuscles. The simplicity of this method of blood-cell counting is its great recommendation, but it is to be noted that the closest attention to all its minute details are imperative if accuracy is desired. Drs. Henry and Nancrede found a combination of Gowers', and Hayem, and Nachet's instruments to facilitate the counting of the cells more than either instrument used by itself. Their combination consisted in utilizing the pipettes belonging to Gowers' instrument, which give a much easier calculation than the one required when the pipettes accompanying the instrument of Hayem and Nachet are employed. The Hayem and Nachet cell with their eye-piece micrometer completes the instrument. They followed Keyes' statement of the calculation as far as concerns the factors of the cell and eye-piece. "The glass cell on the slide is $\frac{1}{5}$ mm. deep. The eye-piece micrometer marks off $\frac{1}{5}$ mm. square; therefore the count of corpuscles must indicate the number contained (in the dilution used) in $\frac{1}{5}$ mm. cube. But $\frac{1}{5}$ mm. cube is $\frac{1}{125}$ of a c. mm.; therefore, the number counted must be multiplied by 125. The blood was diluted by adding 199 parts of fluid to one of blood; therefore, the product above obtained must be again multiplied by 200 to get the number of cells in a c. mm. of pure blood, but instead of multiplying twice, a single multiplication of $125 \times 200 = 25{,}000$ will give the same result." The fluid used to dilute the blood was that recommended by Keyes—fresh urine saturated with borax, filtered, and distilled water added until a specific gravity of 1.020 was obtained.

In estimating the number of corpuscles in the following cases, all of which were patients in the surgical wards of the Episcopal Hospital under the care of Dr. Nancrede, five separate counts were made in each case, and the average taken as the number to represent the condition of the blood under examination. With a view of ascertaining the normal number of white to red corpuscles, as would be indicated by our instrument, we made a series of observations, with blood drawn from persons, who, as far as could be ascertained, were in a perfect state of health. The result obtained from five counts of blood taken from as many different persons gave an average of about 5,000,000 red and 4000 white corpuscles in a cubic millimetre, or one white to 1250 red corpuscles. This proportion of white to red corpuscles is much below that given by physiologists and histologists, and we do not give it as an accurate physiological proportion, since we believe in order to ascertain the exact normal ratio of these elements a different method of counting must be instituted; although to determine an increase or decrease of the *relative* proportion of the corpuscles, under certain conditions, we think the method we have employed is very satisfactory :—

Case 1. W. B., æt. 40, male, suppurating wound of left hand due to injury; the forefinger had been amputated ten days previous to the count. At the time of counting, his temperature was 102.3° F., and pulse 120. The blood was taken from the right middle finger. A cubic millimetre contained—

Red	3,900,000
White	52,050
Ratio	1 to 75

Case 2. O. C., æt. 37, male, has had for seven weeks a paronychia of right thumb, which has caused a necrosis of the distal phalanx. The dead bone was removed twenty-four hours previous to count. At the time of counting his temperature was 99.3° F., and pulse 104. The blood was taken from third finger of right hand. A cubic millimetre contained—

Red	5,725,000
White	15,000
Ratio	1 to 382

Case 3. H. McD., æt. 23, male, was admitted to the Episcopal Hospital on Aug. 13th, with a compound fracture of skull requiring trephining, and a compound comminuted fracture of leg necessitating amputation at the upper third. At the time of counting, Aug. 26th, thirteen days after the operation, the wounds were freely discharging pus, the temperature in the evening was 100.5° F., morning 99.3° F., and pulse 112. The blood was taken from the right middle finger. A cubic millimetre contained—

Red	3,660,000
White	30,000
Ratio	1 to 122

Case 4. J. Y., æt. 44, male; on Aug. 22d, when intoxicated, he passed a foreign body into the urethra. At time of his admittance into the hospital, on Aug. 27th, five days after the introduction of the foreign body, his temperature was 99.6° F., and pulse 92. Some suppura-

tion in the urethra. The count made on the latter date, from blood taken from right middle finger, contained in a cubic millimetre—

Red	5,035,000
White	30,000
Ratio	1 to 167

Case 5. A. B., æt. 55, female, was admitted into the hospital on July 28th, suffering with a lumbar abscess which was then opened. At the time of counting, on Aug. 28th, the abscess was discharging pus very freely, her temperature was 102.2° F., and pulse 122. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	3,455,000
White	40,000
Ratio	1 to 87

Case 6. J. G., æt. 48, male, injury to right hand requiring amputation of three fingers. At the time of counting, twenty-four hours after the operation, the temperature was 100° F., and pulse 108. The blood was taken from left middle finger. A cubic millimetre contained—

Red	5,355,000
White	25,000
Ratio	1 to 215

Case 7. D. F., æt. 40, male, injury of foot requiring amputation of two toes. At time of counting, twenty-four hours after the accident, his temperature was 100.4° F., and pulse 80. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	4,390,000
White	15,000
Ratio	1 to 293

Case 8. A. S., æt. 21, male, suffering with a scalp wound. At the time of counting, twenty-four hours after the injury, his temperature was 99.7° F., and pulse 96. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	5,065,000
White	25,000
Ratio	1 to 203

Case 9. E. W., æt. 50, female, amputation of second toe of right foot, including greater part of its metacarpal bone, on account of an epitheliomatous ulcer. At time of counting, twenty-four hours after the operation, her temperature was 100° F., and pulse 98. The blood was taken from left middle finger. A cubic millimetre contained—

Red	3,970,000
White	15,000
Ratio	1 to 275

Case 10. W. H., æt. 25, male, suffering for two weeks with an abscess on the leg. At the time of counting, the abscess was opened. His temperature was 99.4° F., and pulse 96. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	3,770,000
White	20,000
Ratio	1 to 189

Case 11. J. B., æt. 30, male, simple fracture of left humerus and fibula. At time of counting, forty-eight hours after the accident, his temperature was 99.8° F., and pulse 72. The blood was taken from right middle finger. A cubic millimetre contained—

Red	5,120,000
White	15,000
Ratio	1 to 342

Case 12. M. H., æt. 40, female, wound of hand requiring suturing of tendons. At time of counting, forty-eight hours after the injury, her temperature was 101° F., and pulse 96. The blood was drawn from finger of well hand. A cubic millimetre contained—

Red	4,240,000
White	45,000
Ratio	1 to 95

Case 13. C. M., æt. 52, male, has been suffering for some time with a tumor (carcinomatous) of the post-nasal region involving superior maxillary, ethmoid and sphenoid bones. An operation for the removal of the growth was performed, in which the superior maxillary with portions of the ethmoid and sphenoid bones were removed. At time of counting, forty-eight hours after the operation, his temperature was 100.7° F., and pulse 92. The blood was taken from middle finger of right hand. A cubic millimetre contained—

Red	3,445,000
White	20,000
Ratio	1 to 173

Case 14. W. B., æt. 22, male, burns of the second and third degree on abdomen, thorax, and hands. At the time of counting, twenty-four hours after the accident, his temperature was 101.5° F., and pulse 108. The blood was taken from the left forefinger. A cubic millimetre contained—

Red	4,970,000
White	30,000
Ratio	1 to 166

Case 15. H. H., æt. 22, male, for four days has had a cellulitis of the neck. At the time of counting, his temperature

was 101° F., and pulse 116. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	5,690,000
White	30,000
Ratio	1 to 190

Case 16. G. B., æt. 11, male, injury of the foot, which had been amputated (Pirogoff's operation). At time of counting, forty-eight hours after the operation, his temperature was 101.7° F., and pulse 132. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	3,045,000
White	15,000
Ratio	1 to 203

Case 17. E. P., æt. 48, male, suffering with synovitis and periarthritis of knee-joint, which had, at time of counting, suppurated, and was aspirated; his temperature was 101.2° F., and pulse 96. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	4,995,000
White	45,000
Ratio	1 to 110

Case 18. J. A., æt. 50, male. Twenty-four hours previous to the counting he had met with an accident in which his face, chest, and arms were badly burned by the explosion of powder. At the time of counting his temperature was 101.5° F., and pulse 100. The blood was taken from the left middle finger. A cubic millimetre contained—

Red	4,050,000
White	25,000
Ratio	1 to 162

Case 19. B. S., æt. 21, female, scalp wounds of head sixteen hours previous to count. At time of counting her temperature was 101° F., and pulse 100. The blood was taken from left middle finger. A cubic millimetre contained—

Red	4,060,000
White	35,000
Ratio	1 to 116

In order that any conclusions may be arrived at from these investigations, it becomes necessary to establish a standard of the normal relation between the red and white blood-corpuscles, such as would be demonstrated by the instrument used, and also to demonstrate the existence of an inflammatory condition. In reference to the former, it is seen from our investigations, with the blood of healthy persons, that a ratio of 1 white to 1250 red blood-corpuscles may be taken as the normal relation, that is, as indicated by our instrument. The presence of an inflammatory condition we have verified by the thermometer. The investigations of Dr. Montgomery (page 75) have led to the conclusion that an "increased temperature is an invariable fact in the febrile state."

In the above nineteen cases the temperature varied from 99.3° F. to 102.3° F., and, therefore, in all the inflammatory process was active. The relative number of white to red corpuscles varied from 1 to 75 to 1 to 382.

The actual increase, taking 5,000,000 red as the normal number, varied from 1 to 97 to 1 to 334. If, therefore, we take as the normal number of white to red corpuscles as ascertained by our observations with healthy persons, 1 white to 1250 red, the increase during inflammation is very evident, and if the intensity of the inflammatory process is indicated by the temperature, that is, the higher the temperature the more intense the inflammation, we also find, from our investigations, that, generally, those cases which have the highest temperature have also the greatest increase of white corpuscles.]

There is another change in the blood which may with more confidence be described as at least very frequently an accompaniment of inflammation—viz., that the blood yields more than the normal amount of fibrin, and coagulates with what is called a "buffy coat" on its surface. Perhaps no point is better established in the pathology of the blood than a connection between its yield of fibrin and the presence of acute inflammation: in rheumatic fever, in pneumonia, in bronchitis, in pleurisy, in peritonitis, in quinsy, in erysipelas, the blood's normal yield of fibrin has been found doubled, tripled, quadrupled, quintupled. And under like circumstances the buffy coat has been so habitually observed, that, in days when acute inflammation was much treated by venesection, the contents of the bleeding-basin were an ordinary element in diagnosis, and a buffy coat would be pointed to in justification of the blood-letting which had been performed.

Little is known as to the ultimate meaning of these facts. The buffy coat is an upper layer of clot left colorless by the absence of red corpuscles; and its immediate meaning is, that, through some peculiarity of the blood, the corpuscles have found time, before the beginning of coagulation, to subside in the liquor sanguinis from the top towards the bottom of the basin. Where blood shows the buffy coat, often, from the same cause, its clot has the shape of a truncated cone; the upper or buffy part being firmly contracted and having inverted edges, while the lower strata (where contraction is impeded by the volume of intervening cor-

puscles) become successively broader and looser-textured. Appearances, substantially the same, present themselves to us very frequently in the structure of those clots which form slowly after death in the cavities of the heart and large blood-vessels, and which, because of their slow formation, are destitute of red corpuscles to a more or less considerable depth from their uppermost surface. And in healthy blood, withdrawn from the body, a buffy coat can to some extent be produced by various influences which, retarding coagulation, give more than normal time for the corpuscles thus to settle down. But slowness of coagulation is not, it seems, the only effective influence in the production of a buffy coat. The appearance may be absent even though coagulation has been slow, and it may be present where coagulation has been of normal rapidity. So at least it would seem from the observations of Dr. Stokes:[1] "He noted the appearance of the blood in twenty-seven cases. In fifteen of these the buffy coat presented itself; in twelve it did not. Now in three of these twelve, the coagulation of the blood did not begin till from twenty to forty minutes after it was drawn; and in four others there was no coagulation for eight minutes. So that there was plenty of time for the red particles to have left the fibrin and subsided, but they did not do so. On the other hand, in twelve out of the fifteen cases in which the blood was buffed, the coagulation took place in five minutes; and in the remaining three it was delayed only fourteen minutes." It is evident that results equivalent to those of slow coagulation might be produced in other ways. If the corpuscles had from any cause acquired a special aptitude to subside (such, for instance, as greater weight would give them), the top of a clot would be left colorless, even though coagulation were not delayed; and some observers allege that, in blood drawn during inflammation, the corpuscles show a remarkable disposition to cohere in masses, which, they think, would be apter than separate corpuscles to sink in the containing fluid.

Probably all that is peculiar in the coagulation of blood drawn during inflammation is essentially connected with that altered state of the fluid which occasions its greater yield of fibrin. And the nature of this state is hitherto quite unknown. Whether there be in the blood such an ingredient as fluid fibrin, chemically distinct from the dissolved albumen; whether the fibrin which we can whip from fluid blood be anything more than some of the albumen coagulating at a common temperature, just as the rest of the albumen would coagulate at 160°; whether the greater "*fibriniferousness*" of the blood during inflammation, instead of meaning (as has generally been believed) the increase of a specific ingredient, may not rather mean a general qualitative change in the albumen, rendering it abnormally prone to furnish the coagula which are called fibrinous — these are questions which great chemists are still endeavoring to solve, and which, while unanswered, imply darkness in many important parts of pathology.[1]

[The theory of the coagulation of fibrin advanced by Schmidt, is the one which prevails at the present time, although not yet perfectly demonstrated. This author admits that there are in the blood, besides albumen, two other albuminoid substances—fibrino-plastic and fibro-genetic substances, and that it is a combination of these two substances which causes the coagulation of fibrin. The blood-cells are the bearers of the fibrino-plastic substance, while the fibro-genetic substance exists in the liquor sanguinis. To induce a coagulation of the fibrin, there must be what Schmidt calls a ferment; the material for fermentation is supplied by the fibrino-plastic and fibro-genetic substances, which latter substances, in combination, must be exposed to the action of the ferment, in order to cause a coagulation of the fibrin.]

Nor (whether fibrin be regarded as an ingredient or as a product of the blood) are physiologists altogether agreed as to its meaning in health, or pathologists as to its meaning in inflammation. There are some who believe that the blood is excellent in proportion as it is fibriniferous; that the quantity of fibrin which can be whipped from it represents the degree in which it is available for textural nourishment; that solidifying fibrin is, so to speak, almost incipient tissue; that the blood drawn in inflammation gives, in its fibrinous crust, the sign of being specially adapted to the purpose of additional growth. Others believe (and the writer is most unreservedly among them) that the blood yields more fibrin, not in proportion as it is ripe and perfect, but rather in proportion to quite opposite conditions; that an increased yield of fibrin portrays not perfection, but post-perfection, in the blood; that it corre-

[1] Quoted by Sir T. Watson, Lect., vol. i. p. 155, edit. 1859.

[1] See especially Brücke's paper on the cause of the coagulation of the blood, Brit. For. Med.-Chir. Rev., Jan. 1857, and Virchow's Archiv, vol. xii. And since the first edition of the present paper was written, there have been the very interesting researches of Alex. Schmidt, published in the Arch. f. Anat. u. Phys. of 1861 and 1862.

sponds not to the rise, but to the decline, of albuminous material; that its relations are not with repair, but with waste; that its significance is that of something intermediate between life and excretion. That the fibriniferousness of the blood is undiminished, probably even increased, by bleeding; that it is greatly developed during starvation, during violent fatigue, during diseases essentially anæmic; that its increase under these circumstances of exhaustion, weakness, and inanition is to the full as great as its increase during inflammation; these considerations (to which others might be added) seem conclusive arguments against the view first stated. And when the same considerations are viewed in connection with the general chemistry of inflammatory fever, it seems certain that the alternative view must be right; that the greater fibriniferousness of the blood in inflammation represents actions of devitalization and decay in some albuminous material. Whether this changing material be the inflamed texture gradually dissolving itself into the blood, or be the albumen of the fevered blood itself undergoing accelerated waste, cannot, in the present state of knowledge, be even approximately stated.

C. THE CAUSES OF INFLAMMATION, AND THEIR RESPECTIVE MODES OF ACTION.

As the chemist, referring to common combustion, would not describe its cause to consist in the mere igniting spark which determines its commencement, but would show that conflagration requires the fulfilment of many conditions, whereof only one is represented by that incident; just so the pathologist, in dealing with the so-called causes of inflammation, recognizes that no foreign agent operating on a part of the body would be capable of producing inflammation, unless other conditions were fulfilled by the part whereon it operates.

The powers which concur in producing any given inflammatory process are commonly distinguished as follows, viz.: (1) the *determining or exciting* cause popularly spoken of as *the* cause of the inflammation —being that relatively exterior influence which determines the commencement of an action for which the part by its natural endowments is prepared; and (2) the *predisposing and modifying* conditions—being all such endowments and circumstances of the part as enable and prepare it to inflame. In accordance with this distinction, the present section will be devoted to considering the Causes of Inflammation. Where "cause" is written without any qualifying word, the reader will understand that "determining or exciting cause" is meant; and the expression "determining cause" may be preferred to the expression "exciting cause," with which it is synonymous, in order to avoid the ambiguity which would often result from the double meaning of the latter.

1. *Determining Causes of Inflammation.*

If the practical surgeon, from an exclusively clinical point of view, enumerates the influences which he has known to produce inflammation, they at first seem to be of almost infinite variety and multitude. Classification, however, soon simplifies this chaos. For, on the one hand, the innumerable causes of inflammation may be generalized *according to the sources whence they are derived*—generalized, for instance, into extrinsic and intrinsic causes, with more or less subdivision of each of these chief groups. Or, more philosophically, the causes of inflammation may be classified *according to the nature of the action* by which they produce inflammation in the living body. And since the former mode of arrangement is convenient as an introduction to the latter, the causes of inflammation shall here be considered in that point of view. But, before closing the section, some supplemental remarks will be necessary as to the results of the other kinds of classification.

(a) *Determining Causes of Inflammation, generalized according to the sources whence they come.*

1. Parts of the body which have been cut, stabbed, bruised, torn, rubbed, broken, and dislocated; parts which have had foreign bodies, whether lifeless or parasitic, thrust into unnatural contact with them; parts in which, by heat or other caustic and pungent influences, the chemical constitution or chemical mobility of textures has been affected; these, in their several ways, illustrate one great class of causes of inflammation—causes, namely, which may be generalized as *acts of mechanical and chemical violence* inflicted from without.

2. The influence which, as just mentioned, is exerted on living textures of the body when foreign matters (splinters or bullets, for instance) are intruded on them from without, is sometimes effectually imitated by the influence of peculiar *morbid products* of the body itself. Within the kidneys or bladder, for instance, a

stone concreted from the urine produces just such effects as if it were a pebble from the sea-shore. Its action is that of a foreign body; and in our long catalogue of bodily diseases there are many cases where, with other anatomical relations, like results are produced. Biliary concretions in the liver and gall-bladder often produce inflammation, which sometimes involves the surrounding parts, and may even lead to the discharge of the irritant by ulceration of the abdominal wall. The salivary ducts, too, are subject to calculi, and to inflammation as the result of their presence. The lachrymal apparatus has the same liability. The joints moreover have their concretions, and the serous cavities have theirs; though in both these cases the polished surface of the formation renders its presence comparatively unfelt.

Akin to the above are cases where *retained putrefiable excretions* become irritants to the cavities which contain them; where, for instance (as often happens, sometimes unsuspectedly in connection with chronic paralysis), an imperfectly-relieved bladder has arrears of urine always decomposing in it, rendering the calls of micturition more frequent, provoking a large secretion of mucus which itself becomes an aggravation of the disorder, and at length, unless appropriate treatment be adopted, producing destructive results; or again, where, in connection with stricture of the rectum or some other constipative cause, the retained and decomposing knobs of excrement irritate the mucous membrane of the colon, exciting catarrhal secretion and increased efforts of discharge—a pseudo-diarrhœa, which, unless it be duly diagnosed, may be very erroneously treated.

Of immense importance in the present category are *concretions of blood* (usually extravasated blood) and masses of *tubercle*. Blood, when it is effused among living elements of the body, without exposure to the air, is often little of an irritant; but, to the extent of its influence, it acts as a foreign body, and, where in contact with irritable organs (as we often see with small apoplectic effusions at the roots of nerves), can thus make its presence sufficiently obvious. And for the present purpose miliary tubercles may be regarded as foreign bodies, able to excite textural irritation where they lie. But it is not in their original state that tubercle and effused blood produce their maximum of irritation; it is when decomposition begins either in stagnant blood or in masses of tubercle, that the material, as it softens, has new irritating properties superadded to those of mere extraneity, and becomes to the affected part one of the most disorganizing of influences. The common cause of secondary hemorrhage from tied arteries is an ulceration produced by this irritative transformation of clot; the inflammation of aneurismal sacs with large coagula begins in the same way; and the breaking-up of the lung in phthisis, as more and more tubercle softens in it, is a phenomenon of the same compound sort.

An influence, comparable in some sort to that of concretions and foreign bodies, is the irritation which *parts suddenly deprived of life* produce in the parts next adjoining them.[1] When, for instance, obstruction in the arteries of a limb is such that the extremity dies from anæmia, or when the hand or foot is killed by an extreme action of heat or cold, the dead part, relatively to the adjoining live parts, is as a foreign body; and its elements, which can no longer themselves take part in any vital action, can excite inflammation in those contiguous parts—an inflammation which, so far as it depends on the contact of lifeless matter, becomes aggravated in proportion as that matter (undergoing common post-mortem changes) is rendered also a putrid irritant. A somewhat similar case is that where the crystalline lens, dislocated either by accident or in the barbarous operation of depressing a cataract, becomes an irritant to the parts amid which it is thrust—an irritant which, if at first only mechanical, is liable also to become chemical in proportion as changes occur in the displaced and dead material. A sequestrum of bone differs from soft sloughs in its comparative freedom from decomposing tissue; but, though its influence in irritating contiguous parts is to this extent a simpler one, the resulting irritation is well marked. In Flourens's neat experiments, for instance, when a shaft of bone is made to die by the destruction of its medullary membrane, the dead cylinder of bone becomes a cause of inflammation to the untouched periosteum which invests it; and when, contrariwise, a shaft is made to die, by the destruction of its periosteum, it becomes a cause of inflammation to the untouched medullary membrane which lines it; so that while in the former case reparation proceeds from without, in the latter case it proceeds from within. And with the phenomena of necrosis in the human subject, we have daily opportunities, not only of confirm-

[1] I must guard this passage against being supposed to mean more than it does. It does not purport to explain in full why living parts continuous with dead parts tend to inflame at the line of junction. Later passages will show that I also recognize in this fact one of the most mysterious sympathies of co-organization.

ing these results of experiment, but of noticing how essentially the effects of a sequestrum are the effects of a foreign irritant—how (for instance, with a dead bit of vertebra or of acetabulum) the surrounding parts are thrown into suppuration as though by a driven-in fragment of wood or metal; how abscess follows abscess, and sinus succeeds sinus; the drain and trouble indefinitely continuing, perhaps even to the destruction of life, unless the quasi-foreign body be removed.

Here then we have a second class of causes of inflammation; *retained concretions, excretions, sloughs, and sequestra*—which themselves are results of disease, and which secondarily tend, sometimes by irritative products of their decomposition, but more commonly by their mere dead contact as foreign bodies, to provoke inflammation within the sphere of their influence.

3. Thirdly, inflammation may be caused through *an altered state of the local nerves.* It has long been known that injuries and diseases of the ophthalmic division of the fifth nerve lead to an injection of the conjunctiva, to clouding and ulceration of the cornea, often to final destruction of the globe of the eye, and sometimes to ulceration of the neighboring integument. Similarly it is known that experimental division or bruising of the pneumogastric nerves, at whatever part of their course, induces inflammation of the lungs. Also within the domain of the spinal nerves, disordered nutritive phenomena, sometimes resulting in ulcer, have been seen apparently dependent on local failures of innervation.[1] Eminently this is the case, as Dr. Carter has shown, in limbs affected with anæsthetic leprosy; the numb extremities (which perhaps have little or no motor paralysis) not only being remarkably disposed to suffer vesication and superficial ulceration, but also tending to undergo a gradual destruction which affects first the most distant parts, and begins in them an atrophy of bone.[1] And in this context it is interesting to refer to some experimental researches by Dr. Mantegazza, and others by Drs. Fasce and Amato, on the textural changes which occur in paralyzed limbs: for it appears that within a few weeks after division of the nerve-trunks of an extremity, the bones are considerably reduced in weight, by rarefaction of tissue and predominant loss of earthy constituents, but that this morbid effect is again rectified after the nerve-section has repaired itself.[2]

It is a curious and hitherto a not perfectly solved question how these various injuries of nerves act in producing inflammation.

A first evident fact is that, at least in

[1] "Several years ago I was consulted, at King's College Hospital, by a man who some months previously had torn his ulnar nerve at the inner condyle: his two inner fingers had become swollen and livid with vascular injection. Two years ago I had a female patient here (St. Thomas's Hospital) with disease in a large portion of the lumbar and sciatic plexus of nerves on one side, causing paralysis and anæsthesia of the limb; neuralgia was referred especially to the vicinity of the knee; and at this spot, when I first saw the patient, ulceration had occurred."—J. S., Lect., 1850.

While revising this paper, I am told of an interesting case, where injury to the ulnar nerve at the elbow, five years ago, has been followed till now by local neuralgia with occasional swelling of forearm, and for the last two years by frequent formation there of abscesses.

[1] "On the Symptoms and Morbid Anatomy of Leprosy," by Dr. H. V. Carter: Transact. of Med. and Physical Society of Bombay for the year 1862. "The progressive interstitial absorption, the most frequent and characteristic mode by which the hands and feet become distorted and partly destroyed, always commences at the ends of the fingers and toes (like the anæsthesia), and it would seem that the terminal phalangeal bone is very early affected. After its removal, the altered nail and pulp are transferred by a kind of involution, as it were, to the second segment of the digit, subsequently to the first, which also not unfrequently disappears, and so destruction proceeds. Striking limitations of this process to one side, or its greater progress there, are sometimes seen, corresponding evidently to deeper implication of the median or ulnar nerves, or in the foot to the inner and outer plantar. . . . Necrosis of the phalanges is not uncommon; it begins at or near the joints which then become swollen, foul ulcers appear on their dorsal surface, and fragments of bone, or a whole phalanx, are extruded there; but this process, infinitely more unsightly, though not more destructive than the first described, is not so prevalent as supposed: the two may coexist. In either case the hand or foot is mutilated, nay, well nigh destroyed; in the worst examples it is doubtful if even the carpal bones remain, and a good part of the tarsus may be removed by the same interstitial absorption, accompanied with no pain, swelling, or sores. . . . . The occurrence of ulcers, sometimes large, deep, and foul, and of local gangrene, may be referred to a combination of accidental causes and deficient nervous influence, aided by exposure and want."

[2] I have not yet had an opportunity of reading the original articles to which I here refer, but have my knowledge of them only through abstracts given respectively by Professors Grohe and v. Recklinghausen in the Jahresbericht (Virchow u. Hirsch) for 1867.

the best-known cases, the injured nerve is a sensitive one; and twenty years ago the most probable inference from this fact seemed to be, that inflammation arising in parts deprived of their sensibility was a reflex phenomenon; that the diseased or otherwise injured sensitive nerve conveyed to its ganglionic centre a false impression of the state of distant parts, and that this false impression, acting in a common excito-motory way, determined in the arteries of those distant parts the same changes of calibre, and consequently in the supplied textures the same changes of circulation, as if the misrepresented parts had been really injured. This explanation, however, would scarcely seem admissible: it only pretends to account for the production of hyperæmia in the affected peripheral part; it would not account for the remaining phenomena of inflammation, except by assuming what, in the present state of knowledge, cannot generally be assumed—that hyperæmia, however induced, is in itself a sufficient cause for those phenomena.

Later inquiries, however, have pretended to establish that injuries of sensitive nerves operate still less directly in occasioning the remote changes which are here referred to; that, in fact, there is no direct connection between the injury of the sensitive nerve and the inflammation of the anæsthetized part; that the part inflames merely because it cannot, without sensibility, protect itself against innumerable irritants which are naturally around it; and that if it be artificially protected against this kind of irritation, it will, though insensible, show no special tendency to inflame. Thus, for instance, as regards those very remarkable changes in the conjunctiva and cornea which ensue on certain injuries of the fifth nerve, in some experiments made at Utrecht by Dr. Snellen, under the admirable guidance of Professor Donders, it appeared that if, after division of the nerve, the eyelids of the insensible eye were stitched together, and the still sensitive ear of the animal were fastened as a shield over the part, no ocular inflammation would arise.[1] So again with the pneumonia which has been observed as generally ensuing on injuries of the pneumo-gastric nerve. Prof. Traube, so long ago as 1846–7, made it at least highly probable that this inflammation owes its origin to the circumstance, that, when the action of the vagus is withdrawn, irritative matters pass from the mouth into the air-tubes; for, not only did he detect the presence of such matters in the inflamed lung, but he found that when he had prevented this cause of disturbance (sometimes by cutting the œsophagus across, and sometimes by causing all respiration to go on through a tracheotomy-tube) pneumonia no longer arose within the period to which his experiments extended.[1] Another familiar illustration of the same kind is the catarrhal state of urinary bladder which arises in cases of paralysis; the results of attentive catheterism sometimes seeming to suggest that this inflammation does not depend on any direct action of the nerves on the nutritive changes of the mucous membrane, but on the mere irritation of urine which the paralyzed bladder is not excited or is not able to expel.

The subject, however, is still but imperfectly settled. Against the experiments of Drs. Donders and Snellen, there stands the important assertion of Professor Gräfe[2]—that great exposure and irritation of the cornea (such as is occasioned by cutting away the eyelids and the lachrymal glands) do not, when the trigeminus is uninjured, cause nearly so much inflammation as commonly ensues on section of the nerve; and that the phenomena which result from this unlimited exposure of the globe are also to some extent different in kind from those which follow section of the nerve. It has also been alleged by Dr. Samuel of Königsberg, but hitherto not confirmed by others, that galvanic irritation of the Casserian ganglion (effected in the rabbit by carrying into contact respectively with the sella turcica and the extremity of the petrous portion of the temporal bone two needles which are connected with the wires of a battery) develops an inflammation attended with *augmented sensibility* of the inflaming surfaces of conjunctiva and cornea; and the inference which Dr. Samuel draws from these and other experimental premises which he describes, is, that the inflammation in such cases as we are considering arises through some direct control which nerves, in his opinion, exercise upon textural life.[3]

[1] An admirable illustration of this experiment (accidentally made of peculiar interest by a cross-union which befell the divided nerve-tubule) is given in abstract in the Berlin Centralblatt of 1867, from a paper recently published by Drs. Rosow and Snellen in the Dutch Arch. of Med. and Physiol.

[1] "Beiträge zur experiment. Path. u. Phys." 1846. "Entgegnung auf die Einwürfe," etc. Roser's und Wunderlich's Arch. vii. 6, 1848.

[2] Archiv für Ophthalmologie, 1854.

[3] Samuel, "Ueber den Einfluss der Nerven auf den Entzündungsprocess;" and "Entzündung durch Nervenreizung," in Königsberger Med. Jahrb. 1858; abstracted by Virchow, Archiv, vol. xvi. I may state (though without attaching too much importance to the negative fact) that, in 1860, in several experiments on the Casserian ganglion, per-

Thus, in 1860, when the first edition of this system of surgery was published, all that could be said on the influence of nerve-injuries in producing distant changes of texture, was apparently this: (*a*) that a part, in being deprived of sensibility, becomes specially incapable of protecting itself against mechanical and chemical irritants, some of which are almost certain to affect and inflame it; (*b*) that parts injured in respect of their innervation are likely in consequence to suffer some circulatory disorder with corresponding disturbance of natural temperature, and that perhaps they may thus be thrown into inflammation, or at least be specially predisposed to suffer from various common influences about them; and (*c*) that the possibility of other modes of action, though problematical, is not absolutely excluded. But now, in 1869, as the following remarks will show, the very interesting question is a little less obscure than it was.

Very elaborate studies, which have been made chiefly by Professor Ludwig, of the various nervous influences to which the submaxillary gland is subject, have established quite incontestably (*inter alia*) that the chorda tympani conveys from its ganglionic centre to the gland a specific stimulus to secretion: not an influence indirectly operative through the blood-vessels, but a stimulus directly operative on the secreting glandular substance: and this absolute certainty of central nervous power exerted directly over one sort of vegetative change (that, namely, in which secretion consists) removes all *à priori* improbability from the supposition that centrifugal "trophic" nerves may produce inflammatory changes of texture. And although, so far as I know, Dr. Samuel has not answered the strong objections which were made to his experiments of 1858, some statements made by Dr. Meissner[1] in 1867, tend very strongly, so far as the ophthalmic division of the fifth nerve is concerned, to support Dr. Samuel's belief in nerve-influence directly exerted on tissue. Dr. Meissner declares that that experimental ground, well-worn as it seemed, has yielded him two certainties—first, that injury of the ophthalmic nerve *not producing ophthalmic anæsthesia* may yet produce the characteristic keratitis; and secondly, that an injury *which does produce the anæsthesia* may yet not produce the keratitis; and he further states that, having submitted to careful anatomical examination four animals which had given results of this sort (three where there had been anæsthesia without keratitis, and one where there had been keratitis without anæsthesia), he found that the apparently exceptional results depended on whether he had or had not in his experiment mutilated *one particular portion* of the ophthalmic branch of the nerve—the fibres, namely, which lie near the innermost margin of that branch; and he infers that this portion of the nerve-cord does not, like the remainder, consist of centripetal sensitive fibres, but consists of centrifugal fibres exercising a special "trophic" function. I may add, that if centrifugal trophic nerves are a fact in the organization of the body, we should inquire with particular interest whether such nerves are subject to reflex-affection; and in this point of view some cases which Mr. Salter has recently published, among his remarkable collection of cases of reflex irritation produced by dental disease, deserve, I think, particular consideration: a case, for instance, which he entitles "superficial sloughing of the cheek caused by a carious tooth-stump;" another headed "ulceration of the neck resulting from a carious dens sapientiæ;" and another where the iris underwent permanent change of color in connection with dental neuralgia.[1]

4. In a fourth great group of cases, inflammation results from certain *abnormal properties of the circulating blood*. And these cases are of two chief sorts: for, first, the blood may be a cause of inflammation by reason of certain *deficiencies in its constitution;* and, secondly, it may be a cause of inflammation by reason of its being *charged with some specific irritant*. But, with both sorts equally, the blood is only mediately and passively concerned; so that for practical purposes, the cause of the mal-constitution of the blood is to be regarded as the cause of the inflammation.

First, as regards *defective constitution* of the fluid, there is abundant truth in the popular belief that "poor blood" causes many inflammations, and that the tissues of ill-nourished persons are, when injured, apt to inflame in more than common proportion to the hurt inflicted on them. Not only by the classical experiments of Magendie and Chossat, but by histories of national famine, and habitually by those instances of semi-starvation which not even a well-administered system of poor-laws can altogether prevent,

formed for me in imitation of Dr. Samuel's, I did not see the concurrence, which he describes, of inflammation with hyperæsthesia. And Otto Weber and Tobias have thrown great doubt on the validity of his other experiments.

[1] Zeitschr. f. ration. Medizin (Henle u. Pfeuffer), vol. xxix.

[1] Guy's Hospital Reports, third series, vol. xiii.

we thoroughly know that living textures can be starved into inflammation.

Privation of nitrogenous food is a principal influence of the class now being considered. The corneal ulcers which in Magendie's[1] experiments were observed to arise in dogs fed exclusively on sugar, are important cases in point; and many of the external inflammations which occur so profusely among the poor are probably of similar origin. But the well-known facts of sea scurvy show that absence of nitrogenous food is not the only dietetic fault which may lead to disorganization of texture; and it has been said, though not put beyond controversy, that scurvy depends on privation of vegetable food only in so far as this privation implies an absence of potash from the diet.[2] Liebig has made thoughts like this common in agricultural science, and it certainly deserves inquiry whether any human inflammations, called idiopathic, may be explained on such a basis: whether, for instance, some of those which are vaguely called "scrofulous" — the sore eyes, the sore ears, the sore noses, the whitlows, the congested and catarrhal mucous membranes, which so abound among ill-nourished children—may perhaps depend, not generally on the deficient belly-full of food, but distinctively on the absence or insufficiency of one or two chemical elements.

It is a very interesting question to determine by what manner of action different kinds of privation are able to produce inflammatory excitement in the tissues which they thus affect. In the present state of knowledge, the only conceivable explanation is that the excitement is secondary; that a certain quantity of textural death is the primary and direct result of the privation; and that this first-occurring effect leads to the other as its consequence.

Before quitting the subject of defective nutrition as a cause of inflammation, it is necessary to observe that textural starvation may be partial. Obliteration or narrowing of certain arteries—not enough to cause gangrene in mass, but enough almost entirely to exsanguinate the affected part—may cause chronic inflammatory phenomena. It seems probable, too, that the ulceration which is so frequently attendant on varicose veins of the lower extremity is of somewhat analogous origin; for in these cases the local circulation of blood is materially interfered with—not indeed as being stinted, but as being rendered stagnant; and tissues which cannot renew their supply of blood are physiologically circumstanced almost as if blood were withheld from them.

Extreme cases of ulceration from arterial obstruction are so infrequent that the following case, which was under my care in St. Thomas's Hospital in 1858–9, perhaps deserves to be stated at some length:—

"E. P., æt. thirty-six, had been under observation for twenty months before his death, which took place on the 9th of February, in St. Thomas's Hospital. During this time he had been subject to a peculiar phagedænic process, under which he had lost most of the left side of his face. The disease began in the lower eyelid, and soon involved the globe of the eye; it then extended downwards, destroying the soft parts and exposing the malar, maxillary, and nasal bones, which crumbled away in successive small sequestra; eventually, having opened largely into the nasal and buccal cavities, it attacked the base of the skull, and thus (after many months of extreme suffering) produced death by intra-cranial inflammation. The destruction did not advance uniformly; it was effected by successive little acts of sloughing, which alternated with feeble efforts of repair, and at every access left the patient with a larger and deeper excavation. There was no infiltration of surrounding textures; nor did the granulations, when they formed, ever tend in the smallest degree to exuberance. The meaning of the disease was not arrived at during life. Before the case came under my care, an opinion had been expressed that it was cancerous; but the character of the sore was, I thought, conclusive against this view. The man having undoubtedly suffered syphilis, suspicions were entertained that this taint might be the cause of his local suffering; and various anti-syphilitic drugs were unsuccessfully tried. On post-mortem examination, it appeared certain that the intractable local disease had been a starvation-phenomenon resulting from obstruction of arteries. Of the three vessels arising from the arch of the aorta, the left subclavian was completely obliterated by an old firmly-adherent plug nearly an inch in length, the left carotid communicated with the aorta by an aperture only just capable of admitting an ordinary probe, and the origin of the innominata was reduced by encroaching deposit to one-third of its normal calibre. Beyond their points of origin, these arteries were of proper size and contained but little atheroma. The heart was healthy; but the coats of the thoracic aorta, along its whole length, were so much loaded with earthy deposit as to crackle under pressure. The brain was everywhere perhaps somewhat softer than natural, but with no difference in this respect between its two hemispheres. The lateral ventricles were distended with a turbid purulent fluid; the lining membrane was opaque, and the septum softened almost to diffluence. The base of the brain was coated with a layer of soft yellowish lymph, especially abundant in the middle line and on the under surface of the

[1] See his Précis de Physiologie.

[2] See Dr. Garrod in Edinburgh Monthly Journal, 1848.

middle lobe. The dura mater, corresponding to the latter portion of brain, was, for about two square inches, much discolored, and had its arachnoid surface covered with lymph. The bone beneath it was necrosed to the extent of about a shilling." A case which has many points of resemblance to the preceding is given by Mr. Savory in vol. xxxix. of the Medico-Chirurg. Transactions.

Secondly (as above stated) inflammation may be caused by *blood which contains abnormal irritating ingredients.* When, for instance, arsenic, improperly applied to an external sore, produces its characteristic effects on the gastric mucous membrane, or when the application of a common blister produces strangury, the remote effect depends on the drug having been received into the circulation; and it is from the contact of a blood thus poisoned that the stomach or the kidney inflames. Similarly, if serous inflammations and vomiting and purging are incidental to those later stages of Bright's disease wherein the kidneys are almost incapable of secretion, this is because the blood, charged with the essentials of uneliminated urine, is an irritant to organs which it supplies.

A matter of much interest in the working of many common poisons through the blood is the evidence thus afforded of their different textural affinities; for, in whatever way arsenic or cantharides be introduced into the blood, there is always the same gastric or urinary irritation, and (up to a certain intensity of poisoning) always the same immunity of other organs. This electiveness of stimulant action is not confined to a few drugs having strongly marked poisonous characters, but is a property so widely diffused as to determine the common classification of our *Materia Medica;* being, in fact, the basis of our definition of "purgatives," "emetics," "diuretics," "emmenagogues," and so forth. And though our knowledge that certain drugs specially affect certain organs is of course not intentionally applied to the object of exciting inflammation in the organs which we can thus attack, it is very extensively applied to the object of stimulating them; and we frequently have opportunities of seeing this effect carried to a pitch where it at least verges on inflammation.

It may be convenient in passing to observe that apparently not all drugs with definite textural affinities are *stimulants* to the organs on which they act. Almost of a certainty, there are some which exert a directly opposite action, and which, therefore, if they ever cause inflammation, do so only (after the manner of cold and anæmia) by a power of depressing textural vitality to the point of textural death. Again, a well-known and striking instance of textural affinity is that of madder for growing bone; but here there is no evidence to show that the ordinary process of ossification is in any way affected by the coloring matter which the texture appropriates; and there are similar cases, where, in the course of slow metallic poisoning, particular organs, both secreting and non-secreting, get specially imbued with the metal, yet do not during this process show any excitement of function.

As regards the governing principle of these curious elective affinities, there seems every reason to believe that they are subject to the ordinary laws of chemical combination; that in each case the drug is attracted by something chemically distinctive in the texture on which it acts; and that the resulting stimulation or depression of the texture's vital activity corresponds to a definite affection of the texture's chemical being, probably to mere increase or decrease in its previous rate of transformation and decay. As a physiological corollary of this argument, it may be expected—and practice confirms the expectation—that, where an organ is specially acted on by a drug, the drug shall be chemically demonstrable in the organ or in its secretion. And, subject only to such limitations as are imposed by the imperfections of our means of analysis, it may probably be said, that, wherever inflammation is caused by irritants acting through the blood, such irritants admit of being shown in the products of the inflammation.

In the study of agents which, when in the blood, exert special powers of textural irritation, very particular notice is due to some which effect this result by acting after the manner of *Ferments.* Possibly there are drugs which act in this manner; but the familiar and proven instances, which here require special mention, are those of the so-called "Morbid Poisons," alternately the products and the causes of various specific inflammations. The inhaled "something" which, after a fortnight's lingering in the body, covers the skin and mucous membranes with the pustules of smallpox, or develops the cutaneous blotches and respiratory irritation of measles, or sets the skin and kidneys desquamating and the tonsils sloughing with scarlatina, is as real an exciting cause of inflammation as any stab or bruise or burn. But between the two cases there is this difference: in order that stab or bruise or burn shall cause inflammation, no bodily predisposition (except the fact of being alive) is necessary; but in all living persons alike, on a certain quantity of the hurt, inflammation assuredly results; whereas, on the other hand, the morbid poisons are inoperative, as exciting causes

of inflammation, except where there is a definite bodily predisposition—the contagium of smallpox or measles or scarlatina having no more power to influence the un-predisposed body than yeast has power to ferment alcohol, or to turn pure water into beer.

Between morbid poisons and the common poisons and drugs before spoken of, there is this further difference: arsenic and scammony, for instance, so soon as the blood brings them into contact with the textures on which they operate, produce results proportionate to their quantity, and by doubling or quadrupling the dose we can double or quadruple the effect; whereas with smallpox and scarlatina and measles, the characteristic inflammations often appear quite without proportion to the original dose of ferment —whether some infinitesimal whiff of contagion from a passing patient, or the closest attendance in an atmosphere saturated with odors of the disease. The intensity of effect is essentially dependent on the amount of bodily predisposition which the dose of contagion encounters. And it is a further expression of this dependence to say, that the morbid poisons require "incubation" within the body; not overtly acting at once, when absorbed, as though they were the direct producers of inflammation, but manifesting their influence after days or weeks of latency, during which the bodily predisposition has been gradually fructified by their power. Evidently, then, what has to be said of these morbid poisons may best be said when the predisposing causes of inflammation are generally under review.

Here, too, it is requisite to mention, as a fact in close pathological connection with those just referred to, that there are certain well-marked inflammations, wherein, commonly speaking, textural predisposition is the one notorious fact, and exciting causes altogether elude discovery. Such, for instance, is the common paroxysm of gout; seldom associated with any local action of an ordinary exciting cause of inflammation, but, when thus associated, always showing distinctive phenomena which imply a previously exceptional state of tissue. These cases, like the last, may be more conveniently studied in connection with the predisposing, than with the exciting causes of inflammation.

5. It remains to be mentioned (and the fact must at present be kept separate from facts of morbid poisons acting through the blood) that in various cases inflammation arises as the effect of *direct contagion*.

Everybody knows, for instance, that if two almost invisible scratches be made in the skin, one with a clean lancet, the other with a lancet on which previously there has been collected a minute quantity of secretion from a vaccine vesicle, or from a primary syphilitic sore, the one scratch will have no appreciable result, while the other (except under circumstances which need not now be referred to) will assuredly develop a peculiar train of inflammatory phenomena, due to the inoculation which has been practised. Or, if a little gonorrhœal pus finds its way into the orifice of a healthy urethra, or on to the surface of a healthy conjunctiva, there straightway begins, in the membrane thus acted on, an inflammatory process which often is of great severity. Mr. Robert Ceely tells me that he has twice by inoculation succeeded in communicating ordinary herpes of the lip.

It has been too much the practice to regard these as exceptional facts in the history of inflammation, and to deem them sufficiently accounted for when cow-pox, chancre, and clap are designated "specific" diseases. Waiving for the moment any discussion of what constitutes the undoubted "specificity" of the first-named two inflammations, it may on good grounds be asked with regard to gonorrhœa, whether it be anything more than a common inflammation of the affected membrane — an inflammation, which perhaps first originated, and may with infinite frequency re-originate, from local accidents of dirt and lust; and which, having thus originated, shows a more communicable character than some other catarrhal inflammations—than common cold in the head, for instance—only because genitals come into inoculative contact more frequently than eyes and noses. In the writer's opinion there is ample reason to question the popular impression, that only "specific" inflammations are communicable; much reason for suspecting it, on the contrary, to be a generic and essential property of inflammation that its actions (or some of them) are always in their kind to some extent contagious.

Inflammations of the conjunctiva are, in this point of view, especially deserving of study. It has been extensively imputed to them that they are communicable; and although Dr. Mackenzie reserves the title of "contagious ophthalmia" for that severest variety which has been popularly known as Egyptian, he, in strong terms, claims the property of contagiousness for the common catarrhal ophthalmia of this country. Dr. Guillié proved the contagiousness of the infantile ophthalmia on which his experiments were made; Sir Patrick Macgregor's large experience furnished him with many instances where apparently common ophthalmia displayed contagious properties; and the testimony of these two writers

might properly be here quoted, were it not that the following facts seem briefly to exhaust all sources of doubt on the subject. Among ophthalmic surgeons, especially in Germany, there has been a practice of treating that vasculo-nebulous state of cornea which is called *pannus* by artificially superinducing an attack of acute ophthalmia, and the agency which has been employed for this purpose has been the insertion of some contagious secretion. It is obvious that this method of treatment gives extensive opportunities for testing the communicability of various inflammations; and many such experiments are referred to in Dr. Piringer's work on ophthalmia.[1] This author states that in his own experience, including a few cases in which his assistant had acted for him, he had 87 times (*i. e.*, operating on 87 eyes of 52 different patients) succeeded in exciting conjunctival inflammation by the contact of an inflammatory product; that the material for the operation was taken—in 29 cases from eyes with infantile ophthalmia, in 11 cases from eyes with gonorrhœal ophthalmia, in 2 cases from the urethra of a boy aged three and a half years, in 40 cases from eyes with acute decidedly non-gonorrhœal ophthalmia, in 2 cases from the eye of a child with acute palpebral ophthalmia, in 3 cases from eyes with old-standing chronic ophthalmia. The evidence of such experiments becomes (as Dr. Piringer observes) overwhelming, when it is considered that, in performing them, the secretion was often carried, as we carry vaccine lymph, over a considerable distance from case to case; and that symptoms of ophthalmia not only always began within a few hours of the operation, but began only in that eye which had received the morbid material. Obviously then there is no sense, except one involving a *petitio principii*, in which the word "specific" can be applied to those communicable conjunctival inflammations. And if they were not "specific" but "common" inflammations, where is the reason for believing that the communicability of gonorrhœa constitutes it a "specific" disease?

Of great importance to the present argument are the facts of simple pyæmia—*i. e.*, the phenomena which result from the passage of mere clean pus into the circulation, as distinguished from those more complex and more rapidly fatal results which arise when the pus is admixed with softening fibrin and other putrescent matters. If clean pus be so introduced into a vein that it passes onward with the stream of blood, it gets mechanically arrested in the next capillaries to which the circulation carries it, and there leads to the formation of abscess; and as further intravascular diffusion of pus proceeds from this source, other abscesses arise wherever that pus is carried. Thus, for example, when pus accidentally passes up the vein of an extremity, its corpuscles get more or less completely caught in the capillaries of the lungs, and produce in those organs the earliest effects of their introduction; while such of them as elude that first filter, together perhaps with younger forms of pus which the arrested corpuscles have occasioned to be developed in the lung, pass by the pulmonary veins into the aortic circulation, are diffused by many arteries to many parts of the body, and give rise to the multiple suppurations which are so characteristic of pyæmia. Similarly, when the infective entrance of pus is into some vein of the digestive system (as, for example, into a mesocolic or inferior mesenteric vein, in connection with the ulcers of dysentery), the first stoppage of the inflammatory product is made by the capillaries of the liver, and hepatic abscess is the immediate result; the lung suffering only in proportion as pus passes onward to it from the liver, and other organs suffering only in proportion as the left ventricle transmits to them a purulent blood from the pulmonary circulation. Here, then, primarily, secondarily, and tertiarily, are facts of inflammatory contagion: whithersoever the pus is carried, there unfailingly it produces suppuration—so unfailingly that, as has been said, "if, by way of experiment, you inject a little pus into a vein, you are able to foretell the result just as certainly as if you transferred a handful of frog's spawn from one ditch to another."

But there are other facts—facts almost obtrusively familiar in daily practice—which have hardly yet been appreciated in their bearing on the present subject. What is the meaning of the ordinary "sympathetic" diffusion of inflammatory excitement in the body? When, for instance, in order to make an issue (say, with moxa), we burn a piece of skin the size of a sixpence, why do the surrounding textures to the size of a dollar or more show that they have been disturbed? and why do the nearest lymph-glands become somewhat swollen and sensitive? Why, when inflammation is produced—say, in the skin and cellular membrane of a finger—by the impaction of a splinter of wood, does not this inflammation confine itself to the particles of texture which are in contact with the wood? why does it go on spreading, hour after hour, in wider and wider circles, dying away as vaguely in the distance as the undulations of ruf-

[1] Die Blennorrhœa am Menschenauge. Grätz, 1841.

fled water? and why, two feet off, do the lymph-glands in the axilla swell, and grow painful and tender, and not unfrequently suppurate?

Here are two striking facts of inflammatory contagion. On the one hand, as regards the spread of inflammation according to continuity of tissue, the fact can scarcely be stated in any other ætiological form than this—that such particles of texture as are directly affected by causes of inflammation become capable of exciting inflammation in particles with which they have contact; and the fact, thus stated, embodies the whole doctrine contended for. On the other hand, the fact that lymph-glands in connection with an inflaming part are themselves always more or less thrown into excitement, is assuredly not less suggestive: for, between the primarily inflamed finger and the secondarily inflaming gland in the axilla, there is but one conceivable course or vehicle of influence; and, since the only essential ground of sympathy between the parts consists in the fact that the one of them naturally receives material from the other (namely, those redundancies of local exudation which at last return as lymph to the blood), we have no alternative but to regard this material as the exciting cause of the secondary inflammation—no alternative but to admit that the lymph of an inflamed part is imbued with contagious properties, which enable it in its course towards the circulation to become an irritant to the lymph-glands where it arrives.

It seems probable, then, that the excitement of tissue which constitutes inflammation is a state which essentially tends to diffuse and equalize itself, like heat and other dynamical undulations; that the "sympathy" of continuous parts in one another's inflammation, the "sympathy" of lymph-glands in the inflammation of parts whence they receive lymph, the "sympathy" of the liver with intestinal pyæmia, the "sympathy" of the lung with caval pyæmia, the "sympathy" of numberless parts with aortic pyæmia, the "sympathy" of the entire blood and thereby of the entire body in every larger inflammatory excitement, are cases which illustrate the operation of this tendency within the limits of a single organism; while the facts of gonorrhœal and ophthalmial "contagion" apparently show that the same power may operate beyond the first-affected organism, and that, at least under favorable circumstances, the products of common inflammation, transferred from person to person, can carry with them enough excitement to cause new inflammation where they go.

If, then, this be the case, what difference is there, in respect of the property of contagiousness, between common and specific inflammations? The materials for generalizing on this subject are hitherto so imperfect that it would seem presumptuous to do more than suggest the following considerations:—

First, that in order for common communicable inflammation to be communicated from part to part or from person to person, no predisposition is requisite, nor apparently anything more than that the inflammatory products of the first part or person shall, while still living and active, have sufficient immediate contact with dynamical elements of tissue in the second part or person; whereas, in contrast to this, the specific inflammations cannot engraft themselves by cutaneous inoculation (any more than their inhaled ferments can become operative through the blood) except where certain textural predispositions exist.[1]

Secondly, that the contagiousness of common communicable inflammation seems to be in some special way relative to corpuscular development, and the contagium to be inherent in growing forms; whereas the contagiousness of the specific inflammations seems rather relative to their destructive acts, and the contagium to reside in defunct and dissolving organic compounds.[2]

Thirdly, that, in like manner, the susceptibility to common communicable inflammation seems to reside in the common vitality of the germs of textural growth; whereas the susceptibility to specific contagions seems contingent (as will hereafter be shown) on the parenchymatous presence of lifeless or relatively lifeless organic compounds—compounds, which the various specific contagia, acting on them after the manner of ferments, can convert into their own respective likenesses and thus exhaust from the tissue which contains them; and,

Fourthly (as though by reason of these differences), that in the products of common inoculated inflammation the predominance of pus is a marked and probably

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[1] Mr. Robert Ceely tells me of cases where he has seen eczema proving itself contagious *among members of the same family*, whose predispositions may probably be similar.

[2] Familiar illustrations of what is here stated as to the specific contagia may be found in the microscopy of vaccine and variolous lymph, in their early, as distinguished from their later, stages. And recently Mr. Henry Lee (Med.-Chir. Transact., vol. xlii., p. 450), dealing with the subject from an entirely different point of view, has noticed that simple inoculable chancres furnish a discharge of pus, while chancres which can produce secondary syphilis discharge nothing but débris.

essential fact; whereas the specific contagia seem not to produce suppuration except by indirect inessential ways, and there are well-known cases where the products of specific inoculation tend to become inert almost in proportion as they become corpuscular.

Leaving the above passages as they stood in the edition of 1860, I may now, nine years later, advert to the province of the specific contagia as one in which the ætiology of inflammation has of late been particularly cultivated, and if not yet with final results, at least with most interesting prospects. From a period somewhat anterior to 1860, the kindred chemical subject-matter of common fermentative and putrefactive changes has been under the most critical investigation and controversy; especially as regards the question whether these chemical changes are in any relation of effect or cause to the multiplying microscopic forms which popular observation connects with them; and (according to the common rule which makes controversy hot in proportion as proof is difficult) the old battle of so-called "spontaneous generation" has been raging in these years with extraordinary ardor amid the subtleties and experimental difficulties of that perhaps insoluble question. It would be foreign to the purpose of this book to refer, except in the most general terms, to the opposite views of MM. Pasteur and Pouchet on the origin of such organic forms as are in question, or to the difference which still exists between followers of Schwann and followers of Liebig as to the relation of such forms to the accompanying chemical process; but passing reference to them is necessary, because our present section of the ætiology of inflammation is, in another point of view, also a section of that great discussion. As it was alleged by Schwann that alcoholic fermentations result from the growth of the yeast-plant in the fermentable material, and as it has for the last ten years been contended by Pasteur that all other fermentatory changes (in the common chemical sense of "fermentation") have distinctive, living, and multiplying forms as their respective essential causes: in absence of the germs of which forms, no beginning of the respective chemical process will occur: so now, in our pathological province, various of the specific contagia are said to be, in their essence, living microphytes. Especially Dr. Hallier, of Jena, who for the last three years has been always working at the subject, believes that he has succeeded in botanically identifying the contagia of eight most important diseases: cholera, typhus, typhoid, smallpox, ovine smallpox, vaccinia, syphilis, and scarlatina.[1] An American observer, Dr. Salisbury, describes "two new algoid vegetations," one of which appears to him "to be the specific cause of syphilis, and the other of gonorrhœa."[2] M. Davaine has for some time insisted upon bacteridia as the essential contagium of malignant pustule;[3] and while I am writing this note, I find that Dr. Letzerich, of Mengerskirchen, describes a specific fungus as the efficient cause of diphtheria.[4] There has hardly yet been time (except, perhaps, as regards M. Davaine's case) for much thorough verification to be made of the facts which the just-cited authors rely upon as proof of their doctrine; and even while the facts are still under examination, it may be well to remember that any proven universal occurrence of a specific microphyte in the contagium of a given disease would in the first instance be a fact susceptible of two different interpretations; and that the business of deciding between these two would in its way be of the same sort as that over which MM. Pasteur and Pouchet are still at issue. Meanwhile, nevertheless, the physiological study of the contagia may be productive of practical results. Just as the presence or absence of spermatozoa furnishes empirical ground for opinion as to the fertilizing power of a given testial secretion, so, if recent statements are correct, we may hope that it will be with each specific contagium: the microscope, with artificial culture-experiments, enabling *à priori* judgment to be formed as to the infectiveness of given products, and thus affording a sort of test of the efficiency of pretended disinfectants. Indeed, some of Professor Hallier's experiments on the habits of his supposed noso-fungi are extremely suggestive in this direction.

It may here be noted that researches of a different sort from the above have tended to throw light on the question of the physical state in which the different specific contagia exist. Dr. Sanderson, in his admirable studies of the cattle-plague,

[1] Dr. Hallier's observations as to most of the diseases named in the text are contained in one pamphlet, Parasitologische Untersuchungen, Leipzig, 1868.

[2] American Journal of Medical Sciences, 1868. In the same journal, in 1866, Dr. Salisbury had aimed at proving that intermittent and remittent fevers are caused by the spores of certain species of Palmellæ; and in 1862 (also in the same journal), he had sought to show that measles can be caused by fungi of straw.

[3] See particularly Comptes rendus de l'Acad. lix., 1864.

[4] Virchow's Archiv, vol. xlv., Heft 3, dated Jan. 28, 1869.

showed that the contagium exists in a state not capable of diffusion through a dialyzer; and more recently M. Chauveau has shown that a similar indiffusibility belongs to the vaccine contagium, and to the contagium of ovine smallpox.

[Within the past decade there has been no subject so much written about, so much discussed, so much experimented upon, or one in which there has been, and still is, so much diversity of opinion among surgeons, as that of the germ theory of disease or contagion through organisms —bacteria. We have the extremist, who goes so far as to believe that all diseases are the result of contagion by bacteria, and even that each particular disease has its own particular variety of bacteria. We have the sceptic, who refuses to believe that there are any special organized forms having the power of communicating disease. Again, we have those who do not deny the presence of organisms during the progress of a disease; they look upon such structures not as the originators or cause of the prevailing affection, but as the result or product of the disease. Where so much confusion exists; where scarcely two investigators, studying the same disease, have as yet reached the same conclusions, and when investigations correspond, they are usually differently intrepreted by the experimenters, it would be premature, in face of the existing chaos, which pervades the whole subject, to advance any positive or dogmatic views. That there is much to be expected from further investigations in this direction, we cannot doubt, and that it will, if it has not already, greatly modify both our etiology and treatment of disease, is beyond question.]

(b) *Determining Causes of Inflammation, considered with reference to their modes of action.*

Something may yet be said towards simplifying our estimate of the determining causes of inflammation. For when these influences are regarded from a physiological point of view—when regard is had solely to their respective modes of operation on the living body (and, of course, it is thus alone that they can be pathologically classified)—it seems that they are no longer so various.

Inflammation may have its starting-point from any undue production of textural death: "*undue* production of textural death," because probably in every normal textural change *some* textural death is latent, some supersession of the organic material which acts, some going-away of what is effete, some room-making for what is new. From any *undue* production of this textural death, inflammation, it seems, may originate—equally, whether the texture have received mechanically or chemically some direct and sudden death-blow of an instantly disorganizing kind, or have been more gradually brought to death by powers distinctly stimulant or depressive.

The characteristic power of stimulants and depressors over the textures on which they act—the power of simply causing those textures *to give more or less of their respective typical manifestations in form or function*—this power belongs only to certain doses of the agent. When, for instance, increasing heat or increasing cold is applied to any part of the body, the result is, that, *within a certain range of temperature*, the heat progressively excites without otherwise changing, and the cold progressively reduces, without otherwise changing, the normal activity of the texture on which it acts; but if, in either direction, this range of temperature be exceeded, the texture no longer responds to different degrees of stimulation — no longer gives that essential sign of life.

Model illustrations of this argument (at least as regards function) might be adduced from Dr. Pickford's very interesting experiments on the actions of heat and cold upon the movement of the heart;[1] and the same sort of thing in respect of ciliary motion (with isolated epithelial cells) is well shown by Mr. Lister in his paper On the Early Stages of Inflammation.

The *modus operandi* of cold, in its power of producing inflammation, may be best illustrated by some experiments which I performed in March, 1860. Having occasion in hospital practice to make some issues (such as are commonly made with potash or moxa), I used, in three cases, an application of solidified carbonic acid. With the intense cold of this contact, effected through a gutta-percha tube, and maintained in the three cases respectively for periods of 5½, 16, and 40 minutes, the skin almost instantly became so frozen as to ring like metal. In from 14 to 20 minutes after the application had ceased, the frozen textures had completed their thaw. Blood re-entered them. A swelling, singularly like that of urticaria, then occupied, but only transiently, the exact area which had been acted on, and was soon lost in a general puffy swelling which extended for some distance around. *With all this, the part was entirely without sensibility.* Inflammation presently set itself up in the surrounding parts; but the part on which the cold had acted remained

[1] "Ueber das Verhältniss der Hyperæmie zu dem Schmerze," in Henle u. Pfeuffer's Zeitschr. f. ration. Medizin, vol. x., 1851.

without signs of life, and in due time, having meanwhile suffered no inflammation nor recovered any sensibility, underwent separation as a slough.

And as with heat and cold, so it seems, with all kindred influences. Beyond a limited range of operation (be it chemical, mechanical, or what not) the agencies of textural excitement and the agencies of textural depression become indiscriminately the agencies of textural death; bringing the affected elements of tissue into a state from which they cannot return to their normal irritability—a state regarding which it now matters not whether it have come on them by over-stimulation or over-depression. For they being essentially dead, the organ to which they belong can only (if at all) recover its effectiveness by substituting other elements in their place. And, as the need for substitution is of course proportionate to the void produced by death, so the consequent action ranges in magnitude from the greatest inflammatory processes to the impalpable doings of health.

Omitting for the moment such influences, mechanical or chemical, as are instantly destructive and disorganizing (though in fact they also fall within the scope of what is about to be said), every determining cause of inflammation acts primarily after one of the two patterns referred to: like heat, it operates as a textural stimulant; or like cold, it acts as a textural depressor. According to these two types, the determining causes of inflammation must, at least provisionally, be classified.

Of the *depressive type* our knowledge is much less than of its opposite—so much less, that, were it not for the perfection of the typical case, we might hesitate to rest an argument on its reality. But with the analogy of cold to guide us, as illustrated in the experiments I have cited, we can scarcely doubt but that the power of local anæmia to cause inflammation is exerted after the same pattern. Nor can we have difficulty in believing that drugs which depress the functional activity of textures may, in larger doses, be capable of killing the textural elements which they affect, and of thus becoming causes of inflammation.[1]

Under the *stimulant type* are included all the most familiar causes of inflammation—not only heat, which (as before mentioned), when insufficient to inflame the parts on which it acts, increases their growth and promotes their activity; but likewise mechanical influences, which, in less degree than that wherein they irritate and destroy, may be used (as friction is habitually used) to excite healthy textural action; and chemical agencies—increased oxidation, for instance, which, if it be not enough to inflame, excites the healthiest manifestations of life.

By what method of operation it is that textural death, however produced, and in whatsoever proportion, becomes provocative of textural renewal, we know not. Respecting large palpable quantities, indeed, we constantly have opportunities of observing that dead texture is as a foreign body to the parts about it. But it would be hard to believe that inflammation arises only in the mere mechanical irritativeness of particles primarily killed. The laws of textural sympathy are so very imperfectly known to us that strong assertions would here be out of place; but, even amid the obscurity, it seems an almost necessary expression of organic unity, that formative actions should arise in any segment of the organism in reparative response to sub-segmentary death.[1] If this be so, we may expect that, in proportion as either a depressing or a stimulating influence becomes excessive and mortiferous to any portion of texture, the mother-texture will as of necessity "sympathize," yet sympathize in but one way: that, whether a stimulant gradually excite the textural elements from hypertrophy to death, or a depressor gradually reduce them from languidity to death, in either case *pari passu* the mother-texture will be making its efforts of hypertrophy. Thus apparently the fact is to be explained, that, in examining textures which have undergone a not too explosive inflammation, we find in profusion among their dead elements, elements which, before death, had been engaged in efforts of over-growth. And thus also comes the fact, that, fading away into the distance all around any focus of inflammation, there are seen abundant signs of simple

[1] Undoubtedly this is the case with some drugs of the opposite class—strychnine, for instance. This drug is not familiarly recognized as capable of inflaming the spinal cord, because, when it is given in sufficient doses to produce such an effect, the subject of experiment dies before inflammation can arise. But that such is its tendency may be inferred from the observations of Prof. van der Kolk (infra, p. 101) as to the microscopical state of the cord in animals poisoned with strychnine.

[1] Not only with reference to inflammation, but equally with reference to such hypertrophy as is illustrated in the overgrowth of over-used muscle, and generally with reference to all similar actions, the ætiological formula seems to lie in these two propositions: (1) that textural waste is the provocative of textural renewal; and (2) that the effort of renewal aims at effects somewhat beyond an exact restitution of the wasted quantity of texture—aims at *restoration with increase.*

hypertrophy unmixed with signs of degeneration.

2. *Predisposing Causes of Inflammation.*

There are certain influences, which, though not themselves essentially of an irritant kind, often co-operate with determining causes in producing inflammation: influences, namely, which, if they have possession of the body before certain other agents approach it, render it especially, or even distinctively and exclusively, liable to be inflamed by such agents: so that the various amounts of inflammation excited in different persons by equal quantities of a given determining cause measure the various degrees in which those persons respectively were possessed by such "predisposing" influences. Likewise it is observed that inflammations produced in different persons by similar determining causes, differ, not only in the quantity, but to some extent in the quality of the process; also that certain inflammations have specific peculiarities which cannot be exclusively referred to peculiarities in their determining causes; and whatsoever in these various cases is differential or specific obliges us to infer the influence of "differential or specific predispositions."

Under the title of "predisposing causes of inflammation" must accordingly be included all those influences which (other things being equal) make one man or one tissue apter than another to initiate an inflammatory disease, or to suffer it in a particularly intense or particularly spreading form, or with a particularly long duration, or with a particular tendency to recurrence, or with a tendency to develop particular properties in its products, or other particular phenomena in its course. In other words, the student must consider not only what predisposes to inflammation generally, but likewise what predisposes to special forms and varieties of inflammation.

The influences which may be most distinctly recognized as, in the above sense, predisponent to inflammation are the following: chronic inanition, exhaustive diseases and old age; local disease of arteries, local obstruction of veins, and local defects of innervation; the fact of a part having previously been inflamed; an over-fed state of body; the over-use of strong drinks; the ingestion, by breathing or otherwise, of decomposing organic matters; heat of climate, and perhaps other climatic conditions; specific incidents of bodily development, either (as the so-called humoral dyscrasies) morbidly occurring in particular persons and families, or (as the several susceptibilities to certain febrile infections) normal to the human body at particular periods of life.

It is evident that these various influences could not take part in causing or modifying inflammation, unless first, somehow or other, they acted in the very tissues which inflame. It is an instructive part of the study of inflammation to consider, even at some length, what is the nature of this local action by which each of them becomes efficient; for the result of such consideration is to render it almost certain that, many and various as are the enumerated influences, their modes of operation are only such as one or two general principles can explain.

Weakness of molecular constitution—not "weakness" in a mechanical sense, but "weakness" in the sense of "readiness to die under the action of stimulants and depressors"—this probably is the prime local condition which predisposes to inflammation; and constitutional influences seem capable of conducing to the result only in proportion as they lead to the local establishment of this textural or molecular weakness. The above-given list shows us indeed at a glance, as predisponent to inflammation, various influences which notoriously are of a devitalizing kind; and detailed inquiry renders still more manifest the connection which is thus suggested.

By lowerings of temperature which would not much affect healthy textures, the textures of the ill-fed and aged and feeble are easily depressed to gangrene; and equally it is the case that they inflame under comparatively slight degrees of excitement. And as this inflammation probably starts from a too easy exhaustion and death of the stimulated texture, so likewise in its course it is essentially marked by the predominance of destructive processes; ulceration and gangrene tending in such cases to reach some of their highest developments. The chronic inanition of poverty, with the impoverishment of blood and consequently defective nutrition of tissue which it occasions, is effectually imitated, sometimes with further causes of textural weakness, in persons whom disease has exhausted; and in these persons, equally with the poor and aged, the textures are readily thrown into inflammation: witness the facility with which a fever-patient gets bed-sores, as compared with some unexhausted patient (say, with simple fracture of the lower extremity) who lies, equally bed-ridden, beside him. Evidently too, as regards particular segments of the body, arterial or venous obstruction or arterial rigidity must occasion defects of nourishment very comparable to those which result from general starvation; and it is the fact that parts, having their circulation

of blood thus interfered with, are, like common starved tissues, prone, when irritated, to considerable inflammatory destruction. That parts deprived of their normal innervation are predisposed to inflame, and that this inflammation is particularly apt to involve much destruction of tissue, are facts which already have been discussed, and in illustration of which it is only necessary here to quote the rapid and extensive gangrene which Sir Benjamin Brodie has seen arise in paralyzed parts when suffering even the most inconsiderable pressure: "After injuries of the spinal cord mortification from pressure is very readily induced. In a case in which the spinal cord is injured in the middle of the back, you may find, almost before you suspect that there is anything wrong, a great slough over the sacrum—nay, the pressure of the mattress on the ankles will, in such cases, produce the same mischief. I have known mortification begin in the ankle within twenty-four hours after an injury of the spine."[1]

It is very characteristic of all the influences now specially referred to as "predisposing" to inflammation, that (sometimes perhaps erroneously, but often also by right) they figure likewise among "determining causes" of the process. For, when pushed to excess, not only do they enable inflammation to be excited by determining causes which are almost inappreciably slight; but even they can themselves become direct causes of fatal textural depression, and thus secondarily develop that inflammatory excitement which arises in sympathy with textural death.

That textures which once have been inflamed are specially apt to inflame again, is partly due to the fact that (particularly with dyscrasial inflammations) the old exciting cause is apt again to operate. Partly also it is due to the fact that, in suffering inflammation, they may have permanently lost substance, and thenceforth have become adequate only to lower functional requirements than before.[2] But in part also it probably is due to the fact that, in battling with the previous inflammation, not only were textural elements killed, but other textural elements were wounded and weakened; whence, during the survival of these damaged elements, slighter local disturbances suffice to reinitiate inflammation.

Both with reference to some cases which already have been mentioned, and still more with reference to others which will presently be discussed, it seems highly probable that the textural predisposition to inflame is immediately dependent on chemical peculiarities in the texture. And the peculiarity which seems above all others to be influential for the result is that kind of chemical mobility which depends on the texture being at the time *saturated with certain unstable* (though quiescent) *products of textural waste.* It needs not to be argued that the due defecation of the body is as important to it as its food. But in the present context the student will do well to reflect particularly on the immense amount and complexity of those molecular changes which silently and almost secretly minister to the defecation; how the material of every acting organ changes in its every act, by waste as also by renewal; how products, which eventually appear more or less altered and oxidized in the breath and sweat and urine and feces, are uninterruptedly being thus disengaged and, as it were, moulted from the living textures; how, while the body grows its healthy growth, these declining products are incessantly merging themselves in the blood which washes past their source—merging themselves in it, not as urea and carbonic acid and excretin, but in impermanent forms infinitely more complex. Reflecting on those many runlets of textural drainage, each with its own protean constitution of effete devitalized material, the student will easily conceive how important a mal-condition it may be for any of them to remain stagnant amid the living substance, instead of continuing its progress to excretion; and he will be prepared to follow with interest the analysis of cases in which apparently this imperfect defecation of tissue constitutes the local predisposition to particular forms of inflammation. "Specific incidents of bodily development, either morbidly occurring in particular persons and families, or normal to the human body at particular periods of life," were cited among influences which predispose to inflammation. And, since those developmental conditions are probably of the kind just referred to, the proposed analysis may conveniently begin within them; taking, to illustrate the two sorts of conditions, first, the pathology of gout; and, secondly, the pathology of those eruptive fevers which happen to most persons once, but only once, in life.

Gouty inflammation is characterized by

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[1] See Sir Benj. Brodie's Lectures on Path. and Surg., p. 309.

[2] With the kidneys, for instance: supposing a quantity of structure to have been permanently destroyed by scarlatinal inflammation, any subsequent diuretic influence would have to work by the instrumentality of a smaller quantity of glandular structure. It would consequently affect that structure more intensely, and with more likelihood of causing inflammation, than if it were operating on the original amount of gland.

an explosive local appearance of uric acid; and, on consideration of the circumstances under which this explosion occurs, the inference suggests itself, that materials transformable into uric acid were previously accumulated in the texture which inflames. Perhaps this conclusion might not seem fully justified if regard were only had to the cases in which gouty inflammation begins without any known action of a determining local cause; but the fact is notorious that, in podagrous subjects, any common irritative influence which causes the foot to inflame (a blow, a sprain, an overwalking) may cause it to inflame "specifically"—*i. e.*, may cause an explosive appearance of uric acid where, in common inflammation of equal intensity, there would be merely disintegrated tissue; and we cannot but apply this fact to the elucidation of obscurer cases. Further, the local facts of gout have to be considered in connection with certain points in the general chemistry of the gouty body; and among such points the one of the most present interest is, that habitually during the incubation or latency of gout, there is an imperfect urinary defecation of the system. That an imperfect formation of urinary constituents is at the root of this imperfect discharge of them seems in the highest degree probable. Taking then summarily (so far as relates to our present subject) the facts of gouty inflammation, it seems that certain nitrogenous matters which ought continuously to flow off more or less oxidized by the kidneys are, in persons of gouty habit, apt to be withheld from their final conversion; that in this state of interrupted transformation, wherein perhaps their solubility and transudability are imperfect, they linger saturatingly in those textures of the body where their conversion has been slowest (most of all in extreme parts), and probably to some extent also in the blood; that this storing-up of certain unripe ingredients, or rather antecedents, of the urinary excretion, constitutes the textural predisposition to gout; that presently some pyrexial or other influence, local or general, acting as a sudden stimulus to the languid transformative energy of the part, and overcoming its chemical indolence, initiates that explosive decomposition into urinary ingredients which ought to have been continuous and gentle: a decomposition which, thus beginning in a part, spreads in its own sort to what kindred material there is in the blood (infecting it with a modified inflammatory fever), and thence extends its contagion to other organs which are similarly predisposed.

To place in its proper light the nature of that continuous chemical languidity by which textures are prepared for the crisis of a gouty inflammation, one fact more must be stated. The tendency to gout is hereditary. The plan of constitution and development which every organism derives from its parentage belongs to its chemical not less than to its anatomical being. And just as the visible forms of the body shape themselves according to an inherited pattern, thus, no doubt, may likenesses of offspring to parent be traced also in the chemical functions of the body: likenesses in the rate at which tissues waste into excrement, likenesses in the chemical forms through which they pass, likenesses in the tendency to particular inactivities and abortions of chemical development and decline, likenesses accordingly in those textural predispositions to disease which are constituted by imperfect defecation of texture.

It was above suggested with regard to the chemical contrast which subsists in gout between the two states of paroxysm and inter-paroxysm, that gout in that respect may perhaps be the type of a class of diseases. For there are other diseases, which, like gout, have as an essential character that their textural excitement comes on fitfully, sometimes with almost explosive violence: as that excitement of a nervous centre which marks the paroxysm of epilepsy or mania, and that excitement of articular or serous membranes which marks the attack of rheumatic fever. Such faint indications as chemistry can yet afford on the subject suggest it as not improbable that these diseases may be analogous to gout in the general significance of their phenomena; that some impermanent form of textural refuse, locally arrested and accumulated and acquiring chemical tension, may, here as in gout, be the gist of the state between paroxysms; and that an explosive escape from this morbid repose may be the essential fact in a paroxysm. In the present state of chemical knowledge, these matters must be spoken of with uncertainty; but what may more confidently be stated is, that any paroxysm of the diseases referred to involves an inflammatory change in the affected texture: a vehement and obvious inflammation in the case of rheumatism, a stealthy and microscopical inflammation in the case of epilepsy[1] or mania; that the predisposition

[1] Professor van der Kolk, after poisoning dogs with strychnia, has found the gray matter of the spinal cord in the lumbar region presenting numerous small effusions of blood; some capillaries having given way, while others in their neighborhood were distended to the verge of bursting. And the description

to this inflammatory process is of gradual increase before the attack; that the paroxysm is a crisis of intenser chemical action, involving increased discharges (perhaps specific discharges) from the body; and that with these diseases as with gout, and probably for the same physiological reasons, the peculiar constitution which predisposes to the paroxysm is one which tends to repeat itself according to the laws of hereditary succession.

The well-known phenomena of *smallpox* may be referred to as illustrating what, during our present state of knowledge on the subject, may be considered a second specific kind of textural predisposition to inflammation—that kind, namely, where common exciting causes of inflammation do not seem capable of causing the part to inflame specifically; but where, for the production of this result, it seems necessary that a specific exciting cause should co-operate with the specific textural predisposition. During the febrility of smallpox, the patient eliminates (probably in various states or stages of change) a quantity of material which previously was in the texture of his integument, and in losing this material he loses his susceptibility to smallpox; but in order to undergo the pustular inflammations and attendant waste of material which characterize smallpox, it seems that the predisposed integument must (either by inoculation or through the blood) have been acted on by the waste-products of a similarly predisposed integument already thrown into its course of specific change—in other words, must have been contagiously affected by the morbid poison or ferment of smallpox.

Smallpox is so typical a case of specific contagious inflammation, that the student will do well to consider its facts somewhat minutely in detail.[1] "You receive, perhaps from a long distance, a lancet, on the point of which is a little dry animal matter. This lancet has pricked the pustule of a patient suffering from smallpox, and the contents of the pustule have been allowed to dry on the lancet. Now with this lancet you make a single puncture in the arm of a healthy person, not previously defended by vaccination or otherwise. And what results? On the second day after the operation (says Dr. Gregory), if the part be viewed with a lens, there appears an orange-colored stain about the incision, and the surrounding skin seems contracted. On the following day a minute papular elevation of the skin is perceptible, which on the fourth day is transformed into a vesicle with a depressed centre. The patient perceives an itching in the part. On the sixth day some pain and stiffness are felt in the axilla, proving the absorption of the virus into the general mass of blood. Occasionally on the seventh, but oftener on the eighth day, rigors occur, accompanied sometimes with faintishness, sometimes with pain in the back, headache, or vomiting. The patient complains of a disagreeable taste in the mouth, and the breath is offensive, soon after which the eruption shows itself. If the patient have been a woman, and pregnant, her fœtus will generally have been affected, and, if so, will have died. Finally, when the eruption has developed itself, you find that every one of these new pustules inherits the infective power of that from which they were developed; and thus from one patient you can obtain enough of the morbid poison to diffuse smallpox throughout the habitable globe in an inconceivably short space of time. Observe this immense increase of material; remember the almost imperceptible stain on the original lancet; here you have its material reproduced by a more than million-fold multiplication. Your patient having recovered, suppose you try to infect him again in the course of a few months. You charge your lancet; you make the puncture as before; or you make half a dozen; you accumulate all means of infection about the subject of your experiment; but no longer will he give a single sign of the specific affection. You have got from him all the

which he gives of the state of parts of the medulla oblongata in persons who have suffered from epilepsy seems to show that the epileptic paroxysm involves an almost equally vehement determination of blood to the affected nerve-texture, and often leads to similar rupture of capillaries. It is noticeable that in each of the strychno-tetanic effusions he found a lighter central part, "where (he says) perhaps the blood is diluted by the subsequent issue of serum;" but for which perhaps earlier parts of the present paper may suggest a different explanation. See his work on the Minute Struct. and Funct. of the Spinal Cord and Medulla Oblongata and on Epilepsy, transl. (New Sydenh. Soc.) by Dr. Moore.

[1] The following quotation is from a lecture published by the writer in 1850, but is taken with a few verbal corrections and with this modification, viz., that whereas, in the original, the *blood* exclusively is mentioned as the seat of the material which predisposes to specific contagions, the writer, in transcribing, has altered all passages which imply this doctrine, and has substituted words which imply his present belief (adopted very soon after the publication of that lecture) that the blood does no more than participate in the possession of that predisposing material, and that the textures which are respectively acted on by the specific contagion are themselves the main seats of its accumulation.

phenomena he can give in answer to that particular reagent. I may compare his change of condition to this: Suppose you had a tumbler full of a solution of carbonate of soda, and added an excess of nitric acid; you would get vehement effervescence, more or less, according to the abundance of your dissolved carbonate, and continuing till it had effected the complete disengagement of the gas; then—that particular moment having passed—you might add nitric acid *ad infinitum*, but not another bubble would rise. Just so, your patient refuses to effervesce any more from new infection; certainly for a long time; perhaps for the rest of his life. You re-apply the same cause as produced the phenomena before—identically the same material—and you get a different result. This fact conclusively proves that a change has occurred in the subject of your experiment; a change in him has altered his relations to an unchanged exterior cause; by this personal change the poison is rendered inert to him, while it retains its activity toward others. We have it accordingly demonstrated that for the production of the disease there must be a *specific internal*, as well as a specific external condition; that the former is liable to be exhausted; and, as it becomes exhausted in the production of material phenomena (namely, in the generation of pustules) therefore, obviously, it must itself be a something material, like that outward condition with which it co-operates; that, as the contagium of smallpox is a something material and tangible, so the susceptibility to smallpox is a something material and tangible. Of this predisposing material, whatever it may be, no trace remains in the body when the disease has completed its course; and, since the skin and mucous membrane have been the seats of those inflammatory changes amid which it has melted away, there seems every reason to believe that they were its essential seats. It would further seem probable that the blood must to some extent participate in the same possession; that thus it is able to communicate the influence of inoculation from that part of the integument which has the primary pustule to those other parts which pustulate four or five days afterwards; perhaps also itself to receive direct infection from inhaled contagium, and even in certain cases to develop poisonous products with such rapidity as to destroy life before cutaneous pustulation can begin. Thus we get a general formula for the pathology of smallpox, a certain organic ferment (A), soluble and partially volatile, affects particular relations with (B) an ingredient of the integument and blood, the results of their coming together are the utter destruction of B and the immense increase of A. On the one hand, the contagium augments so much that it is found all over the body, constituting innumerable pustules, and contaminating the breath with its volatile miasma; on the other hand, the inward natural ingredient of the body simultaneously diminishes, and at the end of the process is found totally exhausted. Look at this as a chemical experiment: you add A to B; presently you find that B has vanished, and that A has undergone an immense augmentation. What is the meaning of this? What has become of B? Whence has the new A been derived? It is difficult to avoid the conviction, which arises with almost logical certainty, that the increase of one material and the decrease of the other have stood in essential mutual relation; that, in short, it has been a process of conversion; that the essential relation of the two matters (that derived from without, and that contained within the body) has consisted in the ready convertibility of one into the other; that the specific power of the contagium is its fermentative power of effecting this transformation, and no other. Finally, while that convertible matter, on which the contagium of smallpox effects its assimilative change, does without doubt *normally* form part of the susceptible integument and blood, yet assuredly it is no *essential* constituent of them; for the patient who recovers from smallpox, though with no demonstrable trace of that constituent in his body, returns to at least as good health as before. It may be added, too, that in a certain very small proportion of persons, this natural susceptibility to smallpox appears not to exist."

What in such a study as the above is learnt of the predisposition to variolous inflammation may be applied, *mutatis mutandis*, to the pathology of measles and scarlatina. With these diseases, as with that, it seems probable that a specific texture-held chemical compound (representing some impermanent, though for the time stationary, product of textural waste) constitutes in each case the respective textural predisposition—that as the skin inflames with smallpox only because it contains, and only while it contains, in combination with its texture, certain effete material, so the tonsils and kidneys inflame with scarlatina only because they contain, and only while they contain, in combination with their texture, certain other effete material; and so forth.

Generally, then, respecting these textural predispositions to be inflamed by morbid poisons, and by most of them (as a rule) to be thus affected only once in life, the probable argument may be thus summed up. In the first evolution of certain textures, there normally arise

certain waste-products, which, it seems, under ordinary circumstances, are difficult of destructive conversion, and therefore tend to an indefinite loitering in the part or in the system. As regards each such stuff respectively, one particular stimulus is always effectual to convert it—the contact, namely, of similar stuff already thrown into its specific process of decay. Let this stimulus remain absent, and the subject retains, even apparently to the end of life, the peculiar susceptibility which it alone can awaken and extinguish.[1] Let the stimulus come, and forthwith the stagnant material ferments more or less explosively, commonly with destruction of tissue, often with destruction of life; passing, while it wastes from the body, through a stage of contagiousness similar to that which has stimulated its own change; and leaving the body, when this discharge is accomplished, more or less permanently incapable of renewing the process, or at least only so far capable of renewing it as the predisponent material is capable of being renewed.

It has been intimated that the specific predispositions here spoken of are normal facts in the development of the body. To this rule indeed there may be exceptions, as to other rules in the same category. Just as, by faulty development of bodily forms, hare-lip or spina bifida or twelve fingers or webbed toes may occur as an exceptional phenomenon, so it appears the chemical development may exceptionally omit to complete, or not less exceptionally may hasten to renew, some one of the organic compounds which are respectively fermentable by the several morbid poisons. Such exceptions, however, like the rule itself, mark the developmental source of the predisposition. Either by falling short of what is normal, or by going beyond it, a child may be excepted from the rule of liability once in life to variolous, rubeolar, or scarlatinal inflammation, as he may be excepted from the rule of having ten fingers, or from the rule of having an uncleft palate; and in either case the peculiarity tends to be hereditary. As it is with the one child, so it probably is with his brothers or sisters or some of them, and so it probably was with one or other of his parents: it is part of the family-likeness among them that they do not develop the stuff which makes the liability to measles, or that they develop again and again (if it be removed by successive fermentations) that other stuff which makes the liability to smallpox. The tendency of particular families to suffer particular infections with unusually great, or unusually slight, severity, is another fact of the same signification.[1]

The kind of predisposition to inflame which consists in the textural accumulation of unstable chemical compounds is perhaps further illustrated by other influences in our list. When, for instance, we have the fact before us that great consumers of strong drink, on receiving slight local injuries, especially if the injury be such as to create an open wound, are apt to suffer severe sloughy inflammation, we cannot but advert to what now seems well established respecting the action of alcoholic stimulants—that they retard the excretory changes of tissue, and tend to produce an artificial diathesis in which the organic substance is unduly loaded with refuse. Similarly that kind of albuminous plethora which exists in persons who over-feed and under-exercise their bodies is probably inconsistent with a due defecation of the system; and this consideration naturally connects itself with the fact that such persons are peculiarly susceptible of bronchial and muscular inflammations. So, again, when we see the infants of the poor in crowded town-dwellings suffer many times the mortality which is natural to their period of life, and this mortality mainly from inflammations, we are reminded that, in the animalized atmosphere of those dwellings, respiration can furnish no due excretory cleansing to the blood, nor adequately assist the tissue to get rid of their effete elements. The characteristic intestinal inflammations of cholera and typhoid fever, excited as each of them is by a specific ferment which develops itself in

[1] The existence of that specific stimulus may reasonably be considered to have been an accident in the pathological history of man; for millions, no doubt, have reached the natural term of life, healthy in mind and body, to whom measles, or smallpox, or scarlatina has never come, but who to the very last moment have retained their susceptibility to the disease. And of two alternatives it may perhaps rather seem to have been contemplated, in the scheme of construction for man, that the ingredients in question should indefinitely remain in his body, as inactive, indifferent constituents, than that, for a normal process, they should be worked out of him by the fiery ordeal of fever. When the contagion of measles, after an absence of sixty-five years, was imported into the Faroe Islands, the disease did not show itself as an infantine epidemic, but as an epidemic equally affecting all ages which were junior to the last visitation.

[1] Some exceptions to liability to morbid poisons are, I think, undoubtedly due to the disease having been undergone in utero. A case lately came under my notice of apparent insusceptibility to vaccinia, in spite of repeated attempts of vaccination, in an infant whose mother during its utero-gestation had been revaccinated with full effect.

the decomposition of excrement, strongly suggest the existence of specific textural predispositions, natural or to some extent acquired, and founded on the textural presence of half-eliminated excremental material.[1] Even in that already-discussed predisposition to inflame which is evinced by ill-nourished textures, and still more in that heightened susceptibility to typhus which arises under the influence of starvation, it seems probable that the chemical conditions are of the kind now spoken of, and, at least in the latter case, are of essential importance to the result.[2] That, under many of the circumstances here adverted to, there actually does prevail in certain materials of the body a less than normal fixity of chemical constitution, is not altogether a conclusion from analogy. A very curious generalization bearing on the subject has recently been published by Dr. Inman of Liverpool, to the effect that during many states of debility the patient's excretions are preternaturally prone to decomposition.[1] Dr. Inman especially refers to the alvine discharges, to the urine, and to the organic matters which are eliminated with the breath. And so little is this generalization an effort of medical theory, that Dr. Inman refers his first reflections on the subject to a hint given him by a chemist twelve years ago, during some experimental deodorizations of excrement; for the operator professed to estimate the magnitude of illness with which patients were suffering by the various amounts of putrefaction which their excrements (some hours after evacuation) had undergone; and he alleged that "he had found, in the course of his experiments, that feces decomposed rapidly or otherwise according to the debility of the individual passing them."

Finally, with respect to the climatic conditions which predispose to inflammation, it seems probable that they act only by affecting that chemical mobility of which so much has been said. Thus it may be that continuous atmospheric deficiencies of ozone predispose to those inflammations which are contingent on imperfect defecation of texture. And thus apparently it is that heat of climate greatly favors the outbreak of all inflammations which arise in anything like putrid infection; as is illustrated by Magendie's statement[2] that, by injecting into the bloodvessels two grammes, or even one gramme of putrid material, during very hot weather, he could produce death as certainly as by injecting three, four, or even ten grammes during winter.

[1] Parts of the mucous membrane of the intestinal canal serve as a great disinfectant influence for the blood: fetid contaminations of the body almost invariably excite diarrhœa; and it is a well-known observation of dissectors, that, in flatus voided from their bowels they can recognize the distinctive stench of whatever putrefying matter they may have been busied with—of human gangrene, for instance, or (as the case may be) of porpoise, cuttle-fish, or dog. It is therefore probable that, in persons habitually exposed to putridity, those parts of the mucous membrane of the intestines are constantly in a state more or less approaching saturation with impurities. The urban poor, for instance—frequently dwelling in crowded, unventilated, filthy places, where they breathe a fecal air, and sometimes also drink a fecal water, present one great type of such cases; and whatever chemical changes can occur in fecal matters removed from the system may reasonably be expected to affect, in persons thus circumstanced, that intra-textural excess of fecal or half-fecal matter with which the eliminatory parts of the intestinal surface are charged and sodden. How greatly such persons suffer from the various diarrhœal infections is now well known. Probably the relations of cholera and typhoid fever to specific putrefactions of excrement is as definite as that of smallpox infection to smallpox virus; and the affection of the intestinal mucous membrane by the diarrhœal ferments represents the extension of a putrefactive process from refuse matters without the body to refuse matters within it.

[2] No such ravages have been made by typhus as when it has been associated with famine and, apparently by reason of this association, has prevailed as a national epidemic. There are analogies between the state of persons dwelling in foul atmospheres and the state of persons suffering starvation. "The starved body, which cannot renew the waste of its texture by the ordinary resources of food, probably ekes out its being and maintains the continuity of its organs by stuff, which, under ordinary circumstances of nutrition, would have been discharged as effete. Thus, probably, it comes to consist to an abnormal extent of stale material in a state verging on dissolution. And just as the rags of poverty may by a touch be torn asunder, so those half-starved tissues which they cover fall under very small injuries into disproportionate ulceration and gangrene. The fact that during times of famine masses of population are found with their textures and juices in this state (undefecated because unrenewed) may perhaps have something to do with their fatal susceptibility to typhus; for, under such circumstances, the contagion of this form of disease will spread and multiply (like the contagion of smallpox amid an unprotected population) at a rate quite disproportionate to the sanitary defects of localities."—Papers relating to the Sanitary State of the People of England, 1858, p. xvi.

[1] Foundation for a New Theory and Practice of Medicine. London, 1860, p. 214.

[2] L'Union médicale, 1852, p. 236.

II. The Treatment of Inflammation.

A. GENERAL PRINCIPLES.

Subject to explanations which will presently appear, it may be said that the treatment of inflammation has for its immediate aim *to reduce that excitement of tissue which essentially constitutes the disease.*

And our endeavors to attain this object —endeavors so various that the detail of them can here be only partially attempted —may, as regards their nature, be generalized under two heads which express the main rational rules of antiphlogistic treatment. These rules are the following: *first*, with careful regard to all influences which are operating on the inflamed part, to procure the discontinuance of the special cause of the inflammation, and, as far as possible, to relieve the part from the action of other stimulants; *secondly*, by direct and indirect action on the inflamed part, to counteract there, as far as possible, the working of such irritant causes as remain in operation. And, concurrently with all such etiological treatment of inflammation, this *third* object also has to be fulfilled: that the organized products and waste-products of the disease, and generally its complications and consequences, be so dealt with as to prevent them from reacting hurtfully on the part, or originating other mischief to the body.

1. *To relieve the part from causes of excitement.*

That *inflamed parts spontaneously tend to recovery as soon as inflaming causes are withdrawn from them* is a truth which, simple and rudimentary though it appear, is of more fundamental importance than anything else which can be said in reference to the treatment of inflammation. And if our knowledge of the causes of inflammation were complete, all other than etiological principles of cure would become relatively insignificant.

Under present circumstances, however, there is but one group of cases in which inflammation is knowingly and habitually cured by the mere withdrawal of its cause; and fortunately for the surgeon this group lies for the most part within his province of practice.

The chronic inflammation which is produced in the mucous membrane of the bladder by the presence and friction of an urinary calculus, the acute inflammation which begins in the cornea when some small fragment of steel is driven into its texture, the repeated suppuration and inveterate sinuses which attend the deep-seated retention of any foreign body, or (as operating in the same way) of sequestra of dead bone,—these are common illustrations of the group of cases referred to. Not all the pharmacopœia of antiphlogistics is so effectual in these cases as the mere mechanical act of removing the calculus, the splinter, or the sequestrum.

The thickening and eventually the ulceration of skin which (as in the course of ordinary corns) result from undue pressure and friction on the surface, the inflammation of subcutaneous bursæ under similar circumstances, the nebulous state of cornea which the scrubbing of inverted eyelashes produces, the ulcers which arise in the varicose leg from the stagnifying vertical pressure of an unvalved column of blood, the bronchitis which associates itself with those various kinds of factory-labor wherein the workman has to inhale mechanical or chemical irritants,—these are further familiar cases where morbid conditions are essentially co-enduring with their respective tangible causes, and are best treated by the removal of these causes. Taking from among them, for example, the case where an ulcer of the leg is enlarging and deepening itself day after day by uninterrupted acts of inflammation: let the patient be confined to bed with his leg horizontal or raised; no sooner is the local circulation thus relieved from its previous mechanical impediments than inflammation ceases in the part, and the foulness of the sore almost immediately gives place to healthy granulations which attest the commencement of repair.

It is amongst the highest problems of pathology to discover new groups of cases capable of being treated, like the above, by the simple removal of their respective causes. With the various dyscrasial inflammations, for instance, which are now treated exclusively from an empirical basis, and consequently often without success, how great an achievement it would be, if their immediate causes could be made as palpable as the mechanical causes just spoken of, and could, like them, be distinctly aimed at and destroyed!

Only second in importance to the principle of procuring, where possible, the discontinuance of the special cause of the inflammation, is the kindred principle—that the inflamed part should be as far as possible relieved from the action of other stimulants, and from all inconveniences of posture.

Setting the inflamed part thoroughly at rest, as regards the exercise of its own functional activity, is one great step towards fulfilling this rule. It is thus that, with so much advantage, we exclude

from an inflamed eye the natural stimulus of light. It is thus again that in the case of inflamed joints (especially where there is subarticular caries) the simple expedient of thoroughly immobilizing the part by the application of an appropriate splint will often give chances of recovery which cannot otherwise be attained.

But further: so intimate is the sympathy between all component parts of the living body, that in order to get the fullest measure of repose for any one organ, it is requisite that other organs be restrained from exercise. In proportion as an inflammation is considerable, and especially in proportion as it is attended with febrile symptoms, we find it of importance to obtain thorough quiet for all the animal functions; to reduce to a minimum all muscular movements, all impressions on the senses, all appeals to the intellect or feelings, and all exertions of the will. Probably every inflammation admits of being treated to most advantage when the patient is kept entirely recumbent; but at least in every case where there is appreciable feverishness, it is essential that the patient keep his bed, in a cool and well-ventilated apartment, with every kind of disturbance excluded, and with every available facility for sleep.

It is necessary that the inflamed part be not left in a dependent or constrained posture, but be sufficiently raised to favor its return of blood; and that, by appropriate covering, it be kept free from all irritative contact.

Any existing mal-condition of body by which inflammation or fever may be aggravated will of course at the same time be attended to. And although purgative medicines ought not to be given as a matter of routine, the surgeon will always have regard to the state of the bowels, and particularly will see that vitiated secretions be not retained in them.

Since the publication of the first edition of this work it has been shown with regard to a large class of surgical cases—the class, namely, where open wounds exist or have to be surgically made, that a very important principle of antiphlogistic treatment, in the sense of preventing inflammation, consists in the careful antiseptic management of the part, as specially insisted on by Professor Lister, of Glasgow[1] [now of London]. The improvement is of the simplest sort. The free use of diluted carbolic acid (or any equivalent chemical) to the whole interior of some unpromising wound, and the closing of the wound, so far as circumstances permit, with dressings of the same antiseptic; the dressings, till the wound is healed, only to be removed of necessity, and always with the least possible admission of air, and the antiseptic to be renewed from day to day; this seems no great thing to do: but practically, as those who have adopted the system can certify, it will often insure the recovery of such compound fractures of bone, or such free openings of joints, as, without it, might fairly be despaired of. And in the opening of great abscesses, acute and chronic, the advantages of the same system are not less conspicuous. [See AMPUTATION, Vol. III.]

[1] Lancet, and Brit. Med. Journ., 1867.

2 and 3. *To depress the local action, and obviate its hurtful consequences.*

All treatment hitherto spoken of is, in principle, preventive. The treatment next to be discussed—the treatment to which recourse must be had when the progress of inflammation can no longer be prevented by the removal of its determining cause, is, on the contrary, of the nature of an antidote. The cause not being removable, we have to counteract its effects: to counteract them primarily, as consisting in the local excitement; to counteract them secondarily, as consisting in results which the local excitement originates.

In this curative treatment of inflammation and its results, the following objects, or some of them, are aimed at:—

By depressors and sedatives, either (like cold) outwardly applied to the inflamed part, or (like opium) administered to it through the blood, to directly reduce its excitement and irritability.

By stimulants applied to uninflamed parts of the body, to create counter-excitement, which (as regards attractive influence on the blood, and perhaps also as regards other conditions of existence) shall outbalance the excitement of the inflamed part; or by other derivative means, of which local bleeding is the principal, to attract into collateral channels the flow of blood which otherwise would feed the inflammation.

By general depletory measures — of which bleeding and purging are the principal—and by withdrawal of food, and by use of emetics or nauseants, so to impoverish and weaken the general circulation that the entire body (including of course its inflamed part) shall be brought into circumstances of scantier nourishment, and be freed from vascular tension.

By febrifuge treatment (not necessarily depletive) to relieve the blood from sympathetic derangement, and render it in temperature and constitution as capable as it can be of contributing to resolve the inflammation.

Further, with reference more particularly to special symptoms or results of the inflammatory process, or to special varieties of inflammation, the practitioner may propose to himself one or more of the following objects :—

By cutting into an inflamed part, to relieve it from extreme vascular tension ; or, by uniform mechanical pressure on an inflamed part, or otherwise, to promote the emptying of its vessels.

By cauterizing or intensely irritating an inflamed part, to break the continuity of its particular morbid process.

By the use of antiseptics, locally or generally, to cleanse the sources, and obviate the evil results, of putrid infection.

By surgical operation, where admissible, to effect the discharge of collected inflammatory fluids, and the removal of gangrenous parts, or of parts rendered irreparable and inconvenient, or of parts which threaten life.

By the use of narcotics, to procure the discontinuance of extreme pain.

By the use of specific drugs, to counteract specific dyscrasial states.

By the use of mercury, to develop such a constitutional state as will resist the formation, or cause the destruction of false membranes and adhesions.

Finally, with respect to parts where only the consequences of inflammation remain, to excite by stimulants so far as deficient, the local actions of defecation and repair.

To no exterior influence is textural excitement so directly amenable as to changes of temperature. Cold, continuously applied, is the sedative of every vital manifestation. Under its influence, rhythmical actions become slow or dull, sense and volition slumber, reflex phenomena cease, common growth and embryonic development alike stand still, injured parts are unable to repair themselves. In theory, then, it may be said that continuous cold, locally applied, is in direct and essential opposition to the causes of inflammation. But in practice it is by no means common that cold can be thus used as an antiphlogistic.

Not only are there many cases of inflammation (internal inflammations, for instance) where it is mechanically difficult or impossible to apply the agency of cold ; not only are there many other cases (exanthematic inflammations, for instance) where, rightly or wrongly, the external repressor is deemed dangerous to life ; but, further, the principle on which continuous cold operates is such that, even with external traumatic inflammations, somewhat narrow limits must be assigned to its use. Though clinically it is not always easy to fix these limits with precision, the guiding thought may probably be thus expressed : that, as continuous cold is rather an antidote to the causes of inflammation than a remedy for the resulting changes, so, in order to get full advantage from its use, we must employ it almost from the moment when the causes begin to operate. Thus used in cases to which it is applicable, cold serves, as it were, to subtract something from the efficiency of the exciting causes of inflammation, and to regulate, from its very start, the momentum of the inflammatory process.

In conformity with the above principles, cold is of great antiphlogistic value in the treatment of wounds, including such as are made in surgical operations. Here, commencing its employment almost from the moment of injury, and thus continuously moderating the local temperature, we are enabled to restrict textural activity within the limits of what is just necessary for the adhesive process ; to restrict it in degree, so that it does not run on to suppuration or gangrene ; to restrict it also in extent, so that it does not involve more than the immediate neighborhood of the injured surface.

Among cases in which the power of attaining these results has more than common importance, may be instanced the wounds of large joints, whether made by accidental incision, or designed for the removal of synovial concretions. Under an effective use of cold (together, of course, with absolute immobilization of the limb) many a knee-joint recovers without permanent injury from even some considerable incision.

The antiphlogistic use of cold is often turned to good account, not curatively indeed, but retardatively, in cases (if not too far advanced) of strangulated hernia : a first taxis has been unsuccessful ; the sac and bowel are beginning to inflame and becoming too sensitive for manipulation ; a second surgeon is sent for to operate. Application of cold during the hour or two which may elapse before his coming will not only prevent the development of symptoms, but often effect their temporary reduction to a point at which the taxis may properly be tried again before the knife is had recourse to.

Though it be the fact (as above stated) that in many internal inflammations the local use of cold is mechanically difficult or impossible, yet there are others to which it is applied with success. I am told that in the great hospitals of Vienna and Prague, an ordinary treatment of peritonitis is treatment by local cold ; and it is said by those who have witnessed the practice that the results are of the most satisfactory description.

Local cooling for common antiphlogistic purposes is well effected by water of the

desired temperature. Cloths thus wetted are spread over the surface which is to be acted on. It is essential to the result that these cloths should be kept as nearly as possible at their original low temperature, either by being continuously dripped upon from a reservoir of cold water, or by being very frequently changed or re-wetted by hand. Their surface meanwhile should be freely exposed to the air, or, if necessarily within bed, should have ample space for evaporation secured to it; and arrangements should be made to prevent needless and uncomfortable soaking of the patient's bed and clothing. As regards the temperature of water to be employed, it may range, according to the exigencies of the case, from that which the average healthy hand feels to be decidedly cold—say about 45° F.—to the lowest above congelation. And the maintenance of this temperature in a bedside reservoir of water can be regulated by ice or freezing mixture. Every application which the inflamed part recognizes as cold is, according to its degree, antiphlogistic; but, except in cases where very rapid action is required, the efficiency of the application depends less on extreme degrees of cold than on the continuous and uniform operation of even a moderately reducing temperature. Failing the continuous action of cold, cold is worse than useless. And the too frequent slovenly nursing which lets water-cloths remain for hours unwetted, or swaddles them up under other coverings, is fatal to this method of treatment. The surgeon who wishes to see what can really be effected by the continuous application of cold, must either bestow a little mechanical ingenuity on the construction of a self-acting irrigator for his patient, or must secure such scrupulous attendance at the bedside as to render interruptions impossible. Bladders of pounded ice are sometimes employed, instead of wetted cloths, for the purpose of local refrigeration; but the cold thus produced is greater than, commonly speaking, is necessary, and greater than can for long periods be continued. Perhaps the best use which can be made of ice is, in certain cases of intense onset of inflammation, to make a first local impression which minor degrees of cold will afterwards maintain.

Leaving the above passages as they stood in the first edition of the work, I am glad to be able to mention that since 1860 our appliances for refrigerating inflamed parts have been much improved, and the practice of treating inflammation by the local use of cold has in consequence received very great extension. The improvement has been mainly due to an admirable paper by Professor Esmarch of Kiel (translated in 1861 by Dr. Montgomery for the New Sydenham Society) "On the Use of Cold in Surgery." This paper, besides showing the incomparable surgical advantages which in appropriate cases can be got by a right use of cold, brought into currency the very simple but singularly convenient contrivance of india-rubber bags for the local application of ice: a contrivance which enables us to make effective use of ice with about as little inconvenience as would attach to the employment of a poultice. And having myself now for the last eight years habitually followed Professor Esmarch's improvement in practice, I may confidently say that he does not overrate its advantages; that applied in certain cases separately, and conjoined in certain other cases with the antiseptic management of wounds, it very often enables us to get successful results where of old we should commonly have had failure.

Both as regards a first decision to use cold in the treatment of a particular case of inflammation, and as regards the time when it becomes desirable to discontinue this employment of cold, the surgeon may wisely consult the sensations of his patient. While cold gives comfort, it almost certainly does good; while it gives discomfort, it almost certainly does harm.

Whether, besides cold, there be other agents which act as direct depressors of textural change, and which may on this principle be used as antagonists to the causes of inflammation, is hitherto very imperfectly known. But it seems probable that the antiphlogistic action of OPIUM (and possibly of other narcotics) is somewhat of the same kind; and the present may therefore be a convenient opportunity for referring to it. With opium, as with cold, our best chance of doing good is where we can adopt the treatment almost as soon as a cause of inflammation begins to operate; where, for instance, after some wound, accidental or operative, we can at once bring our patient under the influence of opium, and keep him, as long as necessary, more or less narcotized by renewed doses of the drug. This method of proceeding is often of signal advantage where the peritoneum has been injured; it often constitutes the main feature of after-treatment in cases where ovarian tumors are removed or Cæsarean sections performed, and is often of the utmost benefit after operations for hernia. Its utility under these circumstances is no doubt partly due to its indirect influence in preventing such muscular movement as might displace or irritate the injured parts; for the soporized patient does not care to move from one fixed position, nor do his bowels care to be per-

forming their peristaltic movements. But it seems probable that the same tranquillizing power affects the injured texture itself—renders it, so to speak, less percipient or more tolerant of injury than it otherwise would have been, less disposed to undergo diffuse excitement, less apt to invite increased determination of blood.

There are other uses of opium only inferior to that which has been named. Where inflammation has received a considerable check by depletive treatment, and further measures of the same kind are inadmissible, opium often prevents the textural excitement from rekindling. Where (as is particularly apt to be the case with persons whose constitutions are damaged by irregular and exhaustive modes of life) inflammation is attended rather by nervous irritability than by true feverishness and vascular tension, here, especially if the inflammation be ulcerative or gangrenous, opium, either alone or in aid of any specific drug which an existing specific cachexia requires, may be of indispensable value.

The practice of treating certain inflammations by COUNTER-IRRITANT and other DERIVATIVE measures is believed to represent the application of a pathological principle. Different parts of the body naturally exercise a sort of competition with each other in their several claims on the blood, one part necessarily tending to receive less in proportion as other parts receive more. Undoubtedly to a certain extent this rivalry is exercised through the medium of the general circulation; and thus it is that, for instance, any great determination of blood to the skin may diminish supply to the kidneys. But besides this antagonism effected through the general circulation, there probably are antagonisms of a local character; and parts which are respectively supplied by different contiguously-rising branches of one arterial trunk seem specially able thus to antagonize each other. For, assuming the flow through an arterial trunk to remain the same, one branch or set of branches can only transmit more blood, if simultaneously another branch or set of branches transmit less; and we may well conceive it to be an important function of vaso-motor nerves to provide for the adjustment of this antagonism, by establishing such inter-arterial sympathies that the relative opening of one branch shall determine the relative closure of another. As the claim of each part to receive less or more blood is measured by the degree in which it is indolent or active, so to stimulate a part is the sure way of determining blood to it. *Ubi stimulus, illuc affluxus.* And thus by artificially irritating one part, we may, it is believed, divert blood from another. The irritated part, attracting blood to itself through arteries which open wider to facilitate the process, is supposed to become increasedly antagonistic to all parts which are in arterial sympathy with it, including of course any inflamed part which is thus circumstanced; and in proportion as it succeeds in diverting blood to itself, the arteries of these latter parts are supposed to become (relatively speaking) constricted, and the parts themselves to be relieved from pressure of blood.

Here, then, apparently, is one considerable channel of influence for counter-irritant applications; that, through inter-arterial sympathies which vaso-motor nerves maintain, or contribute to maintain, and in some cases through the general circulation, they tend to divert blood from flowing into the inflamed part. And, so far as the local process depends upon vascular fulness, counter-irritant treatment may, under certain qualifications, be expected, on this principle, to reduce it.

But counter-irritants may have a value beyond this; for probably it is not only as joint competitors for blood that the several bodily parts influence one another's life. Textural excitability perhaps is not so exclusively local but that in this respect also there may be conditions of inter-textural balance; the total excitability of the body at any given moment being perhaps of fixed amount; so that with regard to excitement, just as with regard to blood supply, "*plus*" in one organ would imply "*minus*" in another. Possibly, too, the nerves during counter-irritation may operate in other ways than through arterial contractility to modify the vital actions of parts which counter-irritation is intended to relieve. These possibilities deserve to be borne in mind; lest, relying too exclusively on the derivative element in counter-irritation, we should unduly ignore methods of treatment which seem to require other principles for their explanation.

Surgical appliances of the class under consideration are of three grades of intensity. The *most intense* is illustrated when by caustic potash, or hot iron, or burning moxa, we make a slough of skin; or when, by running a seton under some inches of integument, we establish a track of subcutaneous suppuration; as is often done (and now chiefly in the form of caustic issue) in the neighborhood of joints or of the spine, where cancellous bone-structure is chronically inflamed and carious. A *second* grade is illustrated by the various agents which cause vesication, or, if they be more sparingly used, desquamation of the skin; as when we apply various preparations of cantharides, iodine, or

mustard, to the integument of the chest with the object of relieving some pulmonary or cardiac inflammation. A *third* is illustrated (where perhaps the illustration is not always looked for) in the action of common poultices; as when, on account of a whitlow, we envelop the whole hand and wrist in a poultice, and thus solicit from the radial and ulnar arteries into the collateral circulation a share of the blood which before was being so partially distributed that every beat of the heart was felt as a throb in the finger.

The more intense forms of counter-irritant treatment are so painful that it is well worth while to be critical as to their value. And it deserves more general notice than it has yet received, that some of the most accurate clinical observers of the day are profoundly sceptical on this subject. In various cases of thoracic inflammation, for instance, where thousands of practitioners employ blistering as a matter of course, the unsurpassed authority of Professor Skoda pronounces such treatment to be always powerless for good, though sometimes powerful for harm. And probably a large proportion of treatment by long-continued setons and issues has subsisted, less from any sure knowledge of its doing good than as a remnant of the old belief that morbid humors could thus be set running from the body. Assuredly the whole subject requires careful clinical reconsideration; towards which, in this place, only two suggestions are offered.

In the first place, particularly with regard to the uses of blistering, there is a source of fallacy against which the student will do well to guard himself. Not every cutaneous inflammation excited for surgical purposes is intended to be counter-irritant and derivative. There are cases (presently to be again adverted to) where it acts simply as a further stimulant to the part originally inflamed. When, for instance, we apply strong blistering fluid directly over a knee-joint with chronic inflammatory effusion, the action of the irritant propagates itself, in lessening degrees, through the intervening small thickness of parts, and sensibly affects the synovial surface; where frequently at first it causes some increase of effusion; and where at any rate the desired removal of fluid only begins when the superinduced excitement has begun to subside. And it is by reason of this action that, with regard to superficial parts, blistering, if it does not resolve their inflammation, commonly determines them to suppurate; a fact, sometimes illustrated in the treatment of indolent inguinal buboes, where it may happen that blistering is deliberately used in order to force this alternative on the part, and, either by one way or the other, to bring the inflammation to a close.

Similarly, we may sometimes be proceeding rather too drastically when we blister the walls of the visceral cavities. I have often seen cerebral distress appear to be much aggravated by the application of a blister to the scalp; and it has happened, in making the post-mortem examination of a patient to whose abdomen a blister had been applied, to find on the inner surface of the abdominal wall *a red patch* (probably of more injected muscular substance seen through the peritoneum) corresponding to the area of blistered skin.

In the second place, it deserves full trial whether every intense and consequently painful form of counter-irritation might not be superseded by the employment of other means, less intense, but more extensively applied; whether, for instance, ten inches of poultice may not be equivalent to three inches of blister, or to one inch of issue. For probably among the agencies now spoken of there is none to which we can look with better-grounded confidence than to the diffuse local action of warmth, as supplied by poultices and fomentations; particularly when it can be so administered as to affect a surface of skin very greatly larger than the quantity of inflamed texture which we desire to relieve.

In many chronic—probably also in some acute—inflammations, especially in those which arise from catching cold, or are associated with gout or chronic rheumatism, the excitement of the entire skin by baths of hot air or hot vapor is often of the most striking and immediate benefit. And though in most of these cases the result of the exterior heat is probably something more than mere blood-derivation to the skin, yet not the less on that account are they important illustrations of counter-stimulant treatment.

Pending the better settlement of what is doubtful in the present subject, there are cautions which every one admits to be necessary if the counter-irritant treatment of inflammation is to succeed according to its intention. In proportion, namely, as the counter-irritants which we employ are of severe local action, we must take care—first, that they be not so applied as to involve the inflamed part in their direct irritant operation; and, secondly, that they be not so applied as to aggravate any existing febrile disturbance.

It remains to be stated that there are derivatives which are not counter-stimulant. The abstraction of a very few ounces of blood from the vicinity of an inflamed part often gives relief which apparently is quite out of proportion to

any effect produced on the general circulation. And there seems no way of accounting for this result, unless the action be regarded (on the principles already suggested) as a derivation of blood effected through inter-arterial sympathy.

Local blood-letting is effected by leeches or cupping;[1] of which methods each has its advantages; leeches, that they are commonly less formidable and admit of being more universally applied; cupping, that, if the abstraction of blood is to be large, its quantity can thus be more exactly regulated. It is also believed that cupping exerts its influence through a greater thickness of tissue; and that if we wish for instance, to affect the kidneys, we can better attain our object by cupping than by leeching the loins. Small local abstractions of blood are proper for innumerable cases in which general blood-letting (as requiring to be much more copious in order to produce the same local result) would be wrong or even dangerous. And in cases where recourse is had to general blood-letting, sometimes local blood-letting is thought desirable as an adjunct.

For the objects of local blood-letting it is not necessary that the blood should be drawn actually from the part which is inflamed: to draw blood from the neighborhood answers our purpose: and indeed, where it is possible to apply leeches directly to an inflamed texture, the results are not always as satisfactory as where some uninflamed texture intervenes. It seems very questionable whether inflammation of lymphatic glands is ever benefited by leeching; indeed, in some cases the evil is undoubtedly aggravated. In cases of chronic inflammation, less advantage is got by applying, at once and for all, any given large number of leeches, than by applying fewer leeches several times in succession at intervals of two or three days; a method which (in aid of other necessary treatment) often seems particularly useful with chronic inflammations of the breast and testicle.

Finally, in reference to the subject-matter of the present section, dry-cupping ought to be mentioned. By this procedure, and others which resemble it, we can effect temporary derivations of blood, without at the same time depleting or counter-irritating our patient. And there may be cases for which this unmixed derivatory treatment is more suitable than local bleeding or blistering.

Since the publication of the first edition of this work it has been alleged by different practitioners that in certain cases of inflammation great results may be obtained by directly impeding the afflux of blood to the part. Professor Campbell of New Orleans, who during the American civil war was consulting surgeon to a great Confederate Hospital, has published, as illustrating this law, several cases of gunshot wound of an extremity; where accidentally, because of secondary hemorrhage, he was obliged during severe inflammations of the limb, to tie the main artery, and did so, not on Guthrie's plan of dipping into the wound, but on Hunter's plan, as though for aneurism; and the Hunterian operation, he says, "was chosen with the distinct end in view of combating and checking if possible the destructive progress, and in some the septic tendency of the inflammation. In all of these the pain, the swelling, and the turgescence were almost immediately relieved, and the most remarkable change was soon presented, as seen in the character of the discharges." And he maintains "that no hand, wrist, forearm, or elbow, no foot, ankle, leg, or knee, should ever be amputated for excessive or destructive inflammation—especially those cases resulting from traumatic causes, without resorting, whenever the state of the patient will admit of it, to a previous experimental ligation of the artery supplying the affected region." Professor Vanzetti of Padua, who advocates the treatment of aneurism by continuous digital compression of the artery, has recommended the same method for controlling temporarily the afflux of blood to inflamed parts; and the plan seems to have been followed with success in Paris, and on a large scale in Prague, as well as in his own hands. In England, for the same end, and with satisfactory results, Mr. Moore, of the Middlesex Hospital, in one case used compression, and Mr. Maunder, of the London Hospital, applied a ligature, to the artery.[1]

Depletory treatment includes the oldest and many of the most familiar antiphlogistic measures — blood-letting, purging, vomiting, and starving.

Blood-letting, almost beyond any curative agent, has had strange vicissitudes of repute; sometimes judged to be the one cure for inflammation, sometimes regarded as the deadliest aggravator of what is dangerous in the disease. Reasonable observers of this discord have believed that it must be more apparent than real; that the inflammation spoken

[1] The practice of opening a branch of the temporal artery, with a view to relieve inflammations of the eye, has probably now fallen into deserved disuse.

[1] See New Sydenham Society's Biennial Retrospect of Medicine and Surgery for 1867–8, pp. 284 et seq.

of at one time as cured by bleeding cannot but be different from the inflammation spoken of at another time as rendered fatal by bleeding. And especially Sir T. Watson (always as candid towards the opinions of others as he is enlightened and thoughtful in his own) has strongly stated his belief that "there are waves of time through which the sthenic and asthenic characters of disease prevail in succession." Probably this is the fact. But also it is certain that differences of opinion as to the good or harm of bleeding in inflammation have not, by any means exclusively, been differences between one time and another; for contemporaries, living under the same sky, and practising in the same year on the same disease, have waged controversy on the subject; and not infrequently it has seemed probable that medical juries, inquesting any given dead patient, would divide in equal numbers whether much bleeding or little bleeding had killed the man. "Neither to exclude bleeding, nor to bleed in excess of the present necessity—so to bleed as to secure the advantages of the remedy and to avoid its disadvantages," here, says Sir T. Watson, is "the accredited practice and the precept of all teachers." To estimate that "present necessity" is the art of the skilled practitioner, treating each case according to its own particular claims; an art which cannot be learnt except at the bedside of the sick, and towards which, in the present place, only some general suggestions can be offered.

It is scarcely necessary to say that local nutritive changes are powerfully affected by loss of blood from the general circulation. Occasionally it happens, during some process of repair, that a large accidental hemorrhage occurs—as, for instance, from a stump which, having at first been sloughy, has cleansed itself and is healing by granulation at the time when its main artery gives way; and in any such case we are able to observe how thoroughly the local action is arrested, how the granulations shrink, and how for some days (if the patient survive) the stump looks almost as though it did not belong to a living body. But because this kind of depletion can so suddenly stop the actions of repair, it does not therefore follow that it can with equal facility stop all that we wish to stop in any given inflammatory process; or that blood-letting is an antiphlogistic in that unconditional sense which is implied in some arguments respecting it.[1] The notion, that "if we could completely command the supply of blood to a part, the increased action might be effectually controlled or arrested," cannot even in speculation be admitted without some reserve. The prudent practitioner will incline to remember John Hunter's terse statement of the meaning of all local determinations of blood—"Action creates the necessity for support, and supplies it;" and regarding inflammatory hyperæmia as but the symptom and legitimate consequence of an existing textural excitement, he will doubt as to the expediency of striking with much abruptness at the continuity of this natural dependence. For if the entire circulatory system could gradually be drained of its contents, would not the inflamed part of the body be last of all to become bloodless? would it not to the last remain relatively congested? would it not be more prone than other parts to fall into gangrene from anæmia?

Practically, all impartial observers seem now to agree that, while on the one hand there are inflammations which bleeding can relieve, yet on the other hand there are inflammations which every act of depletion, instead of diminishing, will increase. And the obvious inference from this fact is one which certainly pathology would sanction, that the therapeutical value of blood-letting does not so much consist in its directly controlling inflammatory excitement, as in its controlling some condition which may or may not be concomitant.

The condition which in this point of view deserves especial notice is that state of the circulatory system which (often spoken of by the name of "vascular tension") is characterized by a hard pulse. It has already been suggested, as part of the arrangement by which an inflamed part is able to attract so much blood to itself, that, in proportion as arteries going to the focus of inflammation dilate themselves, collateral arteries become more or less constricted. When inflammation of any magnitude occurs in strong and otherwise healthy subjects, this sympathetic phenomenon diffuses itself widely over the body; the arteries generally (in contrast with those of the inflamed part) getting, by contraction of their circular fibres, into a more or less rigid state of reduced calibre: a state during which the heart's action (being of not less than normal force) gives to the arterial pulse its morbid quality of hardness. This quality of hardness in the general arterial

[1] "Blood is the material by which the increased action of the part is maintained. In the figurative language, which the obviously increased heat has suggested, we may say that it is the fuel by which the fire is kept up. If we could completely command the supply of blood, the increased action might be effectually controlled or arrested."—Lawrence on Diseases of the Eye, 1844, p. 182.

pulse is therefore, according to its different degrees, a standard for estimating the pressure which an inflamed part sustains from the heart's action, and the extent to which that pressure may be aggravating the local disorder. Further, it is a symptom which is directly controlled by bleeding, and which probably never has considerable development except in cases where bleeding can be borne without injury. Generally speaking, then, it seems that any inflammation accompanied by hardness of pulse is likely to be relieved by the abstraction of so much blood as shall remove this sign of vascular tension; that bleeding (or some equivalent measure) becomes necessary in proportion as such an inflammation affects important organs or causes urgent distress;[1] and that, employed on these principles, as distinguished from that of attempting to exsanguinate and starve the inflamed part, blood-letting is an important resource in the treatment of severe inflammations.

Always before having recourse to bleeding we must remember that its effects will be more than momentary. Blood cannot renew itself off-hand; and, while it remains scanty, all actions of repair are enfeebled. Therefore, in proportion as the patient's illness is likely to be protracted and exhaustive, the surgeon will be chary of bleeding for any inflammation which he can affect by less long-acting remedies. Especially he will hesitate to bleed for inflammations which depend on dyscrasial states, and, above all, for those which depend on the infection of morbid poisons. Nor of course will he lightly bleed for inflammations, even though severe, if they be of comparatively unimportant organs. Moreover, it is not conceivable that bleeding can ever be wanted where ulceration or gangrene is in progress. And the delirium of inflammatory fever is in itself no reason for bleeding.

Purgatives are in this country very largely (perhaps somewhat extravagantly) used in the treatment of surgical inflammations. Proportionately to the fluid discharges occasioned by them, they act, like blood-letting, in relief of vascular tension; and often perhaps all the more so, because, besides reducing the volume of the circulation, they may act (for instance, with regard to encephalitis) in a somewhat counter-irritant and derivative way. But this is not the total of their antiphlogistic action. For, since the purged bowels discharge albumen as well as water, the blood is to some extent impoverished by purging. And further, since the intestinal surface is a great emunctory for some effete matters, purging (as will presently again be mentioned) has an important place among febrifuge remedies. It is not at present possible to assign a relative value to these different elements in the antiphlogistic action of purgative medicines; but provisionally we know that purging, in its compound influence, is effective against many inflammations. A sufficient dose of some mercurial, followed after some six hours or more by our old-fashioned "black dose," is a convenient way of getting an antiphlogistic result. And in cases where almost continuous bowel-action is desirable (as for instance, often in cases of encephalitis after injury) this kind of proceeding may be repeated on many successive or alternate days. In the few instances where sudden drastic purging is desired, croton oil (which needs not exclude mercury) may be had recourse to. And there are other cases, though probably not where purging is meant for a depletive remedy, where the patient requires more cordial treatment, and the compound tincture of rhubarb is eligible.

With respect to *starvation* as a part of depletive treatment, but little needs be said. Active depletion on the one hand, and supply of nourishment on the other, are influences in mutual opposition; and, in proportion as depletive measures are thought necessary, food must for the time be thought superfluous. And thus in all grave cases of inflammation the patient instinctively settles the thing for himself: incapable of taking a morsel of food at any time when he is properly being bled; and, at the utmost, not capable of hunger at any time when he is properly being depleted by purging. Therefore in this respect the surgeon has little more to do than to warn the patient's friends against injudiciously pressing him to take food. In cases where the fullest effects of depletion are desired, there is no reason why the patient's drink should exceed the innutritiveness of pure water.

The antiphlogistic action of certain *emetic and nauseant drugs* appears in part very much to resemble the action of blood-letting. Under the action of full doses of antimony, for instance, the pulse, till vomiting occurs, becomes progressively quicker and feebler, till sometimes it is scarcely perceptible; it then almost instantly changes its character, becoming

[1] The peculiarities of the pulmonary circulation render the lung, when its substance is inflamed, more apt than other organs to be embarrassed by fulness of the circulation; and in cases of traumatic pleuro-pneumonia, a given amount of hardness of pulse may be rendered much more significant by the presence of considerable dyspnœa.

fuller and much less rapid, but retaining a marked quality of softness; and during this state, in which any pre-existing vascular tension is for the time effectually removed, there is greatly increased action of the skin, increased secretion of urine, and increased discharge from the bowels.[1] If the inflammation with which we are dealing is one on a very small scale but with very marked painfulness (as, for instance, that which occasions common ear-ache), we find that it is now, perhaps permanently, relieved; that in the great vascular relaxation which has taken place, the little local hyperæmia has ceased to exist. And in more considerable inflammations, the relief, if less complete, is often not less striking. Moreover, by renewed small doses of the drug (which now probably will not produce vomiting) the relaxed state of the arterial system can be maintained, and inflamed parts can thus be continuously kept with all the advantages of lessened vascular tension. Besides these advantages relative to the distribution of blood, there probably are other ways in which antimony serves to reduce acute inflammation, and some of these will hereafter be referred to. The student who wishes fully to appreciate what can be done by this method of treatment should observe it in medical as well as in surgical cases; and perhaps especially he should observe it in cases of pneumonia, since it was here that fifty years ago the Italian *contro-stimolanti* first established its great antiphlogistic virtues. But many ordinary surgical cases will suffice to show him its power; severe cases of acute orchitis, for instance, where the symptoms commonly yield with great rapidity to moderate antimonial treatment. Antimony, like bleeding, is distinctively applicable to such inflammations as are acute, commencing, accompanied with vascular tension, and occurring in unenfeebled subjects.

Some of the properties of antimony are equally possessed by ipecacuanha, and at the onset of many inflammations, especially when we are dealing with children, an emetic of ipecacuanha is often a very convenient way of making a general impression on the vascular system. But as regards any ulterior use of the drug, there is no evidence that ipecacuanha possesses the antiphlogistic powers of antimony; while on the other hand it has this disadvantage, that after-doses are less easily borne without producing renewed vomiting.

Although inflammatory fever be but a symptom and consequence of the local disease, it does not therefore follow that the blood is entirely passive in the process. For the blood, not less than the tissues, contains declining material; and we may well conceive it to be the case that this material or some part of it gets infected by the inflaming tissue, or gets thrown into change by the greater heat of its menstruum, and, if so, contributes, both in respect of temperature and in respect of excretable products, to the signs of general febrility. If this be the case, the inflammatory fever would be capable of reacting injuriously on the inflamed part, and would on this account require treatment. But, even if it be not the case, there are other reasonable grounds for believing that FEBRIFUGE TREATMENT may be serviceable; since probably the circulating blood, in proportion as its febrile temperature is reduced and its effete ingredients are eliminated, becomes more and more capable of contributing (by equalization of effect) to reduce the local heat and to absorb the waste-products of inflammation.

As regards our known means of febrifuge treatment, it must first be noticed that all *depletive measures* tend to reduce the temperature of the blood. During inanition, there is a progressive lowering of temperature; and it is by means of this cooling (as Chossat's classical experiments have shown) that starvation at last produces unconsciousness and death. Marshall Hall's researches on the effects of blood-letting have shown, that during slow exsanguination of the body there is the same decline of temperature.

To some extent the temperature of the blood can be reduced by other than depletive treatment. *Digitalis*, for instance, under many conditions of disease, will, by lowering the pulse, reduce the heat of the body; but it seems certain that where active inflammation exists, the pulse-retarding action of digitalis is by no means easily or uniformly obtained; and the use of the drug in large doses requires so much watchfulness that, under this limitation, little recourse can be had to it.

Effectually and universally the temperature of the blood can be reduced by exposing the surface of the body to *cold air or cold water*. The former influence is made useful in cases of febrility, when we order the sick-room to be kept cool, and the patient (unless we are treating him with diaphoretics) to be but slightly

[1] Comp. Ackermann, quoted by Clarus in Heilmittellehre.

[1] See Clarus's Heilmittellehre, edit. 1860, pp. 597, 603. And compare Spielmann, Des Modifications de la Température animale dans les Maladies fébriles aiguës et chroniques. Strasburg, 1856.

covered with clothing. The latter influence is available in the form of baths or effusions; respecting the febrifuge value of which in surgical practice, it is hitherto, from the absence of sufficient data, not possible to speak with confidence. It is of course evident that, with many surgical fevers, there would be local conditions which might render it practically impossible (even if, on other grounds, it were desirable) to immerse the patient in a bath, or to affuse his entire body with water. But the student, while mindful of this probable restriction in respect of surgical cases, ought to be informed of the very decided febrifuge powers which, abstractly speaking, belong to the method of treatment. Especially it deserves notice that prolonged immersion in water which commonly would not be called cold, even in water as warm as 95° F., may be made the means of reducing febrile temperature.[1]

A remaining important object of febrifuge treatment is, as far as possible, to promote the due excretion of those waste-products which in part probably arise within the febrile blood, and in part accrue to it from the disorganization of the inflamed textures. The tendency of these products, as they become eliminable, is chiefly to the intestinal canal and to the kidneys, and their final discharge from the body can be assisted in the one direction by *laxative medicines* (which need not be of the more depletive kind) and in the other direction by *diluent drinks*. That more latent part of the eliminative process which is prior to the act of excretion can also, it appears, be aided by treatment: *water*, which the febrile patient so thirsts for, is itself an effectual mover of those chemical changes which eventuate in excretion; and *alkalies*, which from time immemorial have enjoyed a febrifuge reputation, are, in the same respect, perhaps the most useful adjuncts which the pharmacopœia can supply. The unlimited allowance of soda-water or potash-water is a method of treatment which the febrile patient commonly finds in the highest degree agreeable, and which probably does as much as can usefully be done to facilitate the chemical clearing of his blood. In some cases of inflammatory fever—perhaps especially in cases of erysipelas—it seems that ammonia has particular advantages, as it is said also to have in the treatment of eruptive fevers. It may be given either alone or together with the fixed alkalies.[1]

Both mercury and antimony belong to the class of medicines which simultaneously increase several discharges from the body, and which (it is hence presumed) promote declensive change in the blood and tissues. They too, in small repeated doses, are often used to fulfil a mere febrifuge intention; but unless there be special reasons for employing drugs which also are depletive and depressing, they probably, for the present purpose, are not preferable to alkalies.

The cases are but few where an inflamed part, not containing pus or sloughs, is *cut into for the mere relief of vascular tension*. In case of severe purulent ophthalmia it used to be deemed good to incise the swollen conjunctiva;[2] and in some cases of throat-inflammation, it was advised to scarify the surface of the tonsils and soft palate; but these expedients are of very doubtful advantage. If inflammation of the skin and subcutaneous texture be diffusing itself widely and rapidly from a first focus of intenser action, where still the inflammation runs high, here, even though as yet there be no pus or slough, a free incision of the most inflamed part often seems to relieve the remainder, and perhaps sometimes averts what otherwise would be a considerable destruction of tissue.

Pressure, which has often been recommended, and often very injuriously tried in the treatment of sundry acute inflammations, is probably now used only in one such case—namely, in that of orchitis; where perhaps it may be, that the quantity of serous effusion which the tunica vaginalis contains renders surgical pressure more tolerable, because more uniform, than we can elsewhere render it. In common cases of gonorrhœal orchitis a patient who cannot or will not keep his bed may move about with comparative impunity (especially when a first good impression has been made by other treat-

[1] This is well shown in one of the cases which Dr. Armitage (in his instructive little volume on Hydropathy in Acute Disease) describes as having been treated by him under Professor Traube in the Charité Hospital of Berlin. A female typhus-patient, having a temperature of 105° F., being put into a bath at 95° F., and kept in it for fifty-seven minutes, lost during this time nearly 2° F. of temperature. So many writings on the present subject have come from inexpert persons and quacks, that it is satisfactory to be able to refer to Dr. Armitage's observations as to those of an accomplished and accurate physician. The wet-sheet packing of the German water-curers, in the form in which they recommend it during febrile conditions of the system, appears to act as a cool bath.

[1] See Mr. Witt's interesting pamphlet on the Use of Ammonia in Scarlet Fever.

[2] See Tyrrell on the "Treatment of Acute Purulent Ophthalmia," Med.-Chir. Transact. vol. xxi.

ment) if the swelling be firmly and quite evenly compressed by an application of adhesive strapping. In chronic inflammations, treatment by pressure is more extensively applicable: not only in those where (as in chronic ulcers of the lower extremity) it antagonizes the mechanical causes of the complaint; but likewise in others (such as chronic inflammation of lymph-glands, and most especially chronic inflammation of the breast) in which the disease is not mechanically caused. In the latter class of cases pressure exerts considerable influence in procuring the removal of morbid tumefaction: an influence which doubtless is not exclusively due to its power of relieving the blood-vessels.

There are certain cases of inflammation —cases which at present do not admit of being well explained, where, irrespectively of any known cause, the process goes on by a sort of local habit, as though the morbid action of to-day were a cause for the morbid action of to-morrow. And, with reference to many of such cases, we practically know that *to interrupt the process* is to cure it. The slight chronic inflammation which occasions ordinary hydrocele of the tunica vaginalis is without known cause, and resists common measures of treatment: the sac may be tapped a hundred times, and a hundred times it will fill again; but let the tapping on any occasion be combined with such an injection of iodine as shall cause an access of acute (non-suppurative) inflammation, and it will generally be found, on the subsidence of this attack, that the hydrocele is permanently cured. In analogous affections of synovial membranes, the same principle of treatment is successfully acted on; and even more strikingly in some cases of irritable ulceration, we find the great advantage of thus "*changing the action of the part.*" Years ago, when beginning surgical practice, I saw this fact illustrated in a way which many times since it has been useful to me to remember. A young man, of generally weak health, had all one side of his neck affected with very painful ulceration—not deep, but extensive and irregularly spreading; during some months all sorts of tonic and contra-scrofulous treatment had been unsuccessfully tried, and latterly, on account of the patient's continued suffering and broken rest, it had been requisite to give opium freely; when at last, after so much fruitless treatment, it occurred to me that perhaps caustic might do good, and the whole large irregularly ulcerated area was in consequence carefully sponged over with a strong solution of nitrate of silver; from which moment (so soon as the smart of the operation had passed away) no more pain was experienced, ulceration was entirely at an end, and without further treatment the surface forthwith proceeded, like any common healing sore, to complete and permanent cicatrization. If due care be taken to discriminate cases to which this principle of treatment may properly be applied, results not less striking than that just quoted may often be seen to follow its adoption: for instance, the most painful paronychial ulceration may often be cured, as though with a specific, if the strong iodine-paint be once thoroughly applied to its surface.

Where the inflamed part is the seat of a putrefactive process (as, of course, is the case wherever gangrene is present) the use of *chlorinous washes*—or, perhaps better, where practicable, the abundant application of powdered *vegetable charcoal* —is to be recommended; and this, not only for deodorizing purposes, but also with a view to reduce as far as possible the entrance of putrid matter into the patient's circulation. Where this putrid infection is occurring (and probably its occurrence in connection with inflammation is not altogether confined to cases where there is gangrene in mass), the resulting diarrhœa seems specifically controllable by *creasote*, internally given.

In treating particular cases of inflammation, it often becomes of great importance to prevent those evils which may accrue, as it were secondarily from the process: evils, that is to say, which *depend on products and results of inflammation.*

Look, for instance, at this common case: A patient has some, perhaps inconsiderable, lumbo-vertebral disease, which occasions an abscess to form in front of his spine; this abscess having no ready outward way to empty itself, goes on from day to day slowly getting larger by addition to its contents, extends within the sheath of the psoas muscle on one side, or perhaps on both sides, of the body, and occupies more and more space till presently it reaches the inner side of the thigh; still restrained by fasciæ which it can only slowly traverse, it grows larger and tighter within the belly, and branches in whatever direction offers least impediment to its increase; so that the patient, whose primary disease affected perhaps not a cubic inch of bone, has got, as a secondary result, an abscess reaching from loins almost to mid-thigh; and when at length this abscess bursts or is opened, there at once begins over the whole wall of its enormous cavity a greatly-excited process of suppuration, under which the

patient rapidly becomes hectic, and oftener dies than recovers. There are evident anatomical reasons why, in the case described, the surgeon can do comparatively little to prevent the dangerous accumulation; but in innumerable other cases, where similar secondary mischief tends to arise, it is almost entirely under control. For, except where pus is out of reach because of important intervening viscera, an incision can at once render accumulation impossible; and it is one of the most imperative rules of sound surgery never to let any reachable abscess enlarge for want of this simple proceeding. Especially this rule claims to be well recognized in the management of articular inflammations. For there was an old surgical superstition that, because wounds of healthy joints are dangerous accidents, therefore abscesses of joints must be specially dangerous to open; and even now sometimes a surgeon can be found who, with this stupid fear, will let the pus of an articular abscess increase and spread till it disorganizes a limb, rather than use his knife to give it a timely escape.

With respect to the *removal of parts* which inflammation has killed, or rendered unpreservable, only a few general remarks are here necessary. Dead soft parts are dealt with by nature so inimitably well, that the surgeon during this natural process has, as a rule, nothing further to do than to take precautions (already adverted to) against putrid infection, and to see that subcutaneous or deeper sloughs are not retained or made noxious by the want of sufficient outward opening. With dead bone the case is different; for, though the living bone becomes discontinuous from the dead as completely as any living soft part from its slough, yet the bony sequestrum, sometimes held by overlying textures, sometimes locked within its capsule or cylinder of callus, almost invariably requires surgical assistance for its removal. And this assistance has to be given with due regard to two considerations: first, that it cannot be effectual till the natural discontinuation is complete—a period which varies from less than three weeks in the case of small superficial sequestra, to perhaps more than two months where the entire thickness of a shaft has to divide itself across; and, secondly, that, when this period has arrived, the sequestrum (since it is a continuing cause of inflammation) ought without delay to be removed.

Also, when an inflamed extremity becomes in its whole thickness gangrenous, bone and soft parts together, surgery must in most instances be the agent of its separation; and here, even more than in the last-mentioned case, the moment for surgical interference requires to be judiciously chosen. In reference to this choice, the only general principle which can be here stated (and it is one which transfers the discussion to future pages of the present work), is, that, in order to amputate with success for gangrene resulting from inflammation, we must wait till the inflammation have ceased to be a spreading process—wait, till nothing more of it be left than that which the gangrenous tissues maintain in their own immediate vicinity. Indeed, not only where inflammation is gangrenous, but commonly with the results of local injury or disease, in proportion as advancing inflammation and inflammatory fever are present, amputation is likely to bring worse evils than it can remove. And with every inflammation which suggests a necessity to amputate, the same principle applies as that which is recognized with inflammatory gangrenes: to wait till nature have arrested the process, and have circumscribed its results by her own line of demarcation.

Long-continued exhaustive suppuration, and perhaps in some very few cases the mere pain and irritativeness of an intractable chronic inflammation, are other conditions which (for instance, where joints are affected) may oblige the surgeon to excise or amputate. But the rules which are appropriate to these cases, as well as the rules which relate to the treatment of parts rendered useless and inconvenient by inflammation, are of too special a kind to be considered in the present essay.

The *pain of inflamed parts* is very often sufficiently considerable to require that *special means should be taken for its relief*. And often under such circumstances, unless in the individual case there be reasons against it, opium, or other like treatment, must be had recourse to. But before concluding that this is necessary (especially where severe pain outlasts or outmeasures the apparent intensity of an inflammation) the surgeon will carefully consider whether, instead of thus palliating the patient's pain, he cannot in other ways more effectually remove it. Some of the worst pains depend on the presence of pus: a patient, who perhaps for years has been racked with pain in one or other end of his tibia to an extent that no narcotics could render tolerable, is instantly and permanently relieved by the trephine, which lets out, it may be, not a teaspoonful of confined pus from within the bone; and in innumerable suppurations of soft parts (breasts, joints, tonsils, lymph-glands, even cellular membrane) all which is severest in the pain depends upon the

pressure of pus, and may be ended with the stroke of a bistoury. Other extreme pains have other removable causes: the pain of simple subarticular caries, so severe while the joint is let move, becomes tolerable under the proper use of the splint; and in the frequent case where subarticular caries is kept up by the constant irritation of some small sequestrum of bone, its terrible pain will cease if this sequestrum be withdrawn. And there are other cases where some atrocious pain, together with the inflammation which it characterizes, can be treated (as our next section will show) by drugs more effectual than opium.

Inflammatory pain is often relieved by the moist warmth of poultices and fomentations. The diffuse derivative action thus exerted is, no doubt, often the immediate cause of the relief. In some cases, especially in those of superficial phlegmonoid inflammation, the relaxative influence which moist warmth exerts on the contractile tissue of the skin may have more to do with the results.

Poultices and fomentations at higher degrees of temperature—indeed as hot as the patient can bear them—are used by some practitioners in order to accelerate the formation and discharge of pus. And there can be no doubt that the stimulus of heat thus applied may produce the proposed effects—may quicken the actions which give pus, and may expedite the ulcerative changes which allow an abscess to empty itself. But in both respects the method of treatment is objectionable; for, on the one hand, if pus have not formed, its formation ought, if possible, to be prevented; and, on the other hand, if pus have formed, the course is infinitely better that at once we discharge it by incision, than that, during the slow action of poultices, we allow the abscess painfully to become perhaps many times larger than it needs have been.[1]

There are kinds of inflammation which have their *specific antidotes*. The periostitis and rupial phagedæna of tertiary syphilis cease when iodide of potassium begins to act. The paroxysm of gout is relieved by colchicum. Many chronic skin-inflammations are more or less amenable to arsenic. Others are tractable by pitch. Sometimes a fibrous inflammation (perhaps especially sclero-iritis) will abruptly yield to a few doses of turpentine. Mercurial inflammation of the mouth is cured by chlorate of potash. For some chronic rheumatisms, sulphur seems to be a cure. The inflammations of secondary syphilis are subdued by mercury. Occasionally, but not often, an inflammation called scrofulous will suddenly begin to go when cod-liver oil is given. To some cases of inflammation, alcoholic stimulants are a benefit; to others, the tonic influence of quinine. Malarious neuralgia (but how far this is inflammatory may be questioned) is stopped by the drugs which cure common ague; and other cases, more or less satisfactory, might be adduced to the same general effect.

It would be impossible here to discuss at any length either the circumstances under which these several specific agencies may be employed, or the intimate nature of their respective operations on the body. As regards the former set of questions, the writer can only refer to treatises on the several specific diseases which he has named; and as regards the latter set of questions, he will only venture on one general remark. Wherever we oppose inflammation by means which, comparatively speaking, are intelligible to us, our agencies are those which depress common textural excitement; hence in the obscurer cases now referred to, where textural excitement yields to remedies of a different description—to remedies which are non-depressive or even stimulant in their kind (as, for instance, where psoriasis yields to arsenic, or iritis to Chios turpentine)—it seems reasonable to infer that the action of the remedy is not primarily on the inflammation itself, but rather on those hitherto not analyzed conditions of dyscrasia or ferment wherein the inflammation has its cause.

And this argument suggests that here may be the most convenient place to mention how great an influence is exerted on some dyscrasial states by the treatment, or part of the treatment, which is popularly known as the "*water-cure*." Much bequacked though this subject has been, the student ought to be aware that, according to the testimony of very competent observers, the water-cure is, for good or bad, an active method of treatment; which, if practised during health, causes the body to undergo considerable chemical changes; and which, if medically applied, is capable of greatly aggravating or greatly amending different morbid conditions. It is declared to be highly effective against some of the chronic and recurrent inflammations just adverted to—especially against gout and rheumatism, and against those skin-diseases and those so-called "congestions" of liver and mucous mem-

[1] It is a venerable practice which the writer ventures to condemn. More than two thousand years ago, Aristotle seems to have been puzzled by the therapeutics of poulticing. Why is it (he asks) that one man ripens inflammation with heat, while another man resolves it with cold? διὰ τί τὰς αὐτὰς φλεγμασίας οἱ μὲν ψύχοντες ὑγιάζουσιν, οἱ δὲ θερμαίνοντες πέπτουσιν; Problemat. 45.

branes which depend on the same dyscrasiæ, or on kindred constitutional states. Reverting to what in a former section was argued with regard to the pathology of gout and some allied disorders, we cannot be surprised that certain measures of water-treatment should enjoy a reputation for curing them. For assuredly our first practical step from those pathological considerations would be to inquire after means *whereby defective textural waste can be accelerated;* and probably such means are presented in their simplest and most manageable form in some of the appliances of the water-cure. With increased water-drinking there is increased discharge of solids in the urine. Böcker, experimenting on himself during two successive weeks, with different allowances of water, found that while he was drinking daily about five pints of water, the solids of his urine were nearly 10 per cent. more than when he drank only about two pints of water; the urea being increased by fully a twelfth part, the chlorides by nearly a third, and the sulphates and phosphates less considerably. Again, as regards the external appliances: Dr. Lehmann, of Rolandseck, says that after a cold sitz-bath lasting a quarter of an hour (during which about a fifth of the entire surface of the skin is reduced as much as 12° F. in temperature) the urea and uric acid are both, for the time, greatly increased—a result which he attributes to greater aëration of the blood, consequent on the respiration being accelerated, while the pulse is rendered less frequent; and he estimates that 67½ grains of carbon must be oxidized to repair the loss of temperature which the bath occasions. The protracted sudorific packings are said to produce a more considerable waste of tissue than any other of the measures employed. Persons who have given most attention to these methods of treatment affirm that during their action, in cases to which they are suitable, the healthy nutrition of the body is promoted, in proportion as refuse-materials are actively disengaged. They insist upon this as an essential distinction between water-treatment, and treatment by mercury or other eliminative drugs.

Purgative preparations of mercury have already been mentioned as capable of contributing to the depletive treatment of inflammation. But other antiphlogistic merits are claimed for mercury: and although the validity of these claims is hitherto far from being settled, there is much consent of authority in favor of at least one part of them: viz., that the *constitutional action of mercury opposes the organizing efforts of inflammation;* and that accordingly, if the drug be given in such sufficient excessive quantities as to produce a certain amount of mercurial cachexia, inflammation will be prevented from leaving behind it those adhesions and false membranes which, when left, are often permanent injuries to health.

It is scarcely possible at present to speak with certainty on this alleged action of mercury. Perhaps some who defend it have too easily taken it for granted that what they see of it in syphilitic iritis (where the existing morbid poison is specifically subject to mercury) must be common to it under all circumstances. Perhaps, too, some have not sufficiently discriminated between the organizing actions of inflammation and the mere laminar concretion of fibrin—have not sufficiently made sure that what has seemed to be the disintegration of nascent tissue has not been mere dissolution and removal of clot. Perhaps, moreover, many who speak very confidently on the power of mercury to cause the removal of inflammatory effusions are not aware of the great efforts which unassisted nature makes for this purpose; efforts, so great and so successful, that some of the first living physicians, even in dealing with pleuritic and pericarditic effusions, trust almost entirely to the natural process, and busy themselves with little more than repairing the patient's general health.

On the other hand, in such glimmering light as pathology can throw on the subject, it does not seem impossible that mercury may act in the manner described. That its common primary action is to prevent or unsettle some chemical combination within the body—some combination which stands in close antecedence to more than one special secretion—has been taken, almost by common consent, as the hypothesis whereby to account for its power of stimulating simultaneously many different secreting organs. And it is no great enlargement of this hypothesis to believe that the drug, with prolonged use, can extend its disintegrative action from lower to higher organic combinations—from material which is nearest excretion to material which forms part of structure. Contemporary experience fortunately does not give us on this point such crucial experiments as were made by the salivators of fifty years back; but tradition says, that, in patients whose mercurialism was measured by the potful, granulating surfaces used often to change their action to sloughing, broken bones would be withheld from repairing themselves, and even united fractures would sometimes re-dissever their union. For these reasons one hesitates to deny that mercury can disorganize even the completest texture which adhesive inflam-

mation leaves behind it. But it seems little likely that any fully organized new tissue can be thus changed, except under an amount of cachexia which would equally endanger the vitality of other tissues; and there certainly is not room to suppose that mercurialism, in its common antiphlogistic use, borders so very closely on poisoning. Accordingly, if mercurial cachexia in its lesser degrees, and independently of the purging which may attend it, has a real effect on inflammatory products, this effect probably relates only to such products as are not organized, and perhaps is nothing more than the giving of some special assistance to the dissolution and removal of fibrin.

How far it is desirable, for the sake of this, or any proved or believed advantage, to have recourse to mercurialism as a part of common antiphlogistic treatment, is a practical question on which there are wide differences of opinion. For myself, I may confess, that, for many past years in my treatment of inflammation (excepting, of course, certain syphilitic inflammations) I have never had recourse to mercurialism. I had previously got to regard its influence as often the very reverse of febrifuge;[1] and my utmost use of mercury in inflammation has long been only to give it in single purgative doses. But it would be unjust to form an estimate of the value of mercury from an exclusively surgical practice; and the following paragraphs from Sir T. Watson's admirable Lectures on the Practice of Physic, besides showing that in this different field of practice, opinions, entitled to the highest respect, are expressed in favor of the drug, may also serve to teach on the best authority how such opinions are practically carried into effect. "Next to bloodletting, as a remedy, and of vastly superior value upon the whole to purgation, in serious inflammations of various kinds, is mercury. This mineral is really a very powerful agent in controlling inflammation; especially acute, phlegmonous, adhesive inflammation, such as glues parts together, and spoils the texture of organs" . . . "and if we, in our turn, could always bridle and limit the influence of mercury itself, it would be a still more valuable resource." . . . "In common adhesive inflammation, whether of the serous or the areolar tissues, whenever, in fact, you have reason to suppose that coagulable lymph is effused, or about to be effused, and mischief is likely to result from its presence, then you may expect benefit from the proper administration of mercury; as an auxiliary, however, to blood-letting, when blood-letting is indicated—not as a substitute for it. On the other hand, mercury is likely to be hurtful in those forms of disease where the morbid action approximates to its own action; in cases of erysipelatous inflammation having a disposition to gangrene; in scrofulous diseases, in inflammatory complaints attended with general debility, and an irritable condition of the nervous system, or a manifest tendency to take on a low and typhus-like character. When we have to contend with acute inflammation, and desire to prevent or arrest the deposition of coagulable lymph, our object is, after such bleeding as may have been proper, to bring the system as speedily as possible under the specific influence of mercury." . . . "We know that the whole system has been brought under the specific influence of mercury as soon as its effects become even slightly perceptible in the gums and in the breath of the patient; and in adults we cannot be sure of it before. The gums grow red and spongy; the patient complains that his gums are sore; and that he has a metallic taste, a taste like that of copper, in his mouth. At the same time, an unpleasant and very peculiar fetor, easily recognized again when it has been once perceived, is smelt in his breath. These symptoms are enough; you need not in general look for any more decided affection of the mouth, such as ulceration of the gums, swelling of the glands beneath the jaw and of the tongue, and a profuse flow of saliva" . . . "all that is requisite is that the gums should become distinctly tender, and that the mercurial fetor should be unequivocally manifest, and that these symptoms should be kept up for a certain time. Now this is best effected, usually, by giving some form of mercury in equal and repeated doses, by the mouth. For urgent cases calomel is the best form in which it can be administered: two or three grains given every four or six hours will generally suffice to touch the gums in the course of thirty-six or forty-eight hours. If it act as a purgative, its specific effect upon the whole system will be postponed by that circumstance; and it then becomes expedient to combine with it just so much opium as will prevent its passing off by the bowels. A quarter of a grain of opium with two

[1] An observation made by Dr. Spielmann (op. cit. p. 22) seems, in this respect, to be of considerable interest: "Lorsque dans le cours d'une maladie aiguë contre laquelle on a employé la mercure, il survient une stomatite mercurielle, la température subit un accroissement notable. De 39 à 40° elle est portée à 41 à 42°. Cette élévation anormale persiste aussi longtemps que la stomatite. Il faut donc se garder d'attribuer l'élévation de la température ou la recrudescence de la fièvre à une exacerbation de la maladie primitive."

grains of calomel—or a third of a grain of opium with three or four grains of calomel—will generally be sufficient to restrain the purgative operation of the latter. When a speedier effect is desirable we give larger doses; such as five or ten grains every three, or even every two, hours; or we combine mercurial inunction with the exhibition of calomel by the mouth. It is impossible to lay down any precise rule that will fit all cases. Blue pill, or else the hydrargyrum cum cretâ, may, in certain cases, be preferable to calomel; but they must be given in greater quantity." . . . "This mode of administering mercury, so as to affect the system at large, is eminently useful in many instances of acute phlegmonous inflammation, after bleeding has been carried as far as the circumstances of the case may warrant. I repeat that it must not be allowed to supersede blood-letting, when that remedy would of itself be eligible. Previous bleeding renders the body more readily susceptible of the influence of mercury; and the operation of the mercury comes in aid of the salutary effect of the abstraction of blood. The two remedies accomplish by their joint power what neither of them might be able to accomplish singly." . . . "Mercury is of great service in many cases of chronic inflammation; and I may repeat here the observation I formerly made when speaking of blood-letting—that the treatment must keep pace, as it were, with the disease. When textures have been slowly altered by a gradual deposition of coagulable lymph, we should gain little or nothing by suddenly or speedily salivating our patient. The lymph, if it can be dispersed at all, must be gradually taken up again; and mercury, given with the view of promoting its absorption, must be slowly and gradually introduced into the system, and its specific influence, when at length it is felt, must be sustained for a considerable length of time. You must not expect any good, but the contrary, from the exhibition of mercury in scrofulous inflammations; and where the scrofulous diathesis is well marked, you should be cautious in giving mercury at any time. But I am certain that many men are too scrupulous in this respect; and that, through over-tenderness of your patient's constitution, you may risk his life, by withholding mercury because he shows tokens of scrofula. You may recollect my stating that scrofulous persons are not exempt from attacks of common inflammation; and in some such cases the possible aggravation of their general ill-health, by mercury, is not to be put in competition with the immediate danger from the local inflammation. I have again and again seen scrofulous patients benefited by moderate salivation; which, if it proved injurious at all to their general condition, was certainly less injurious than the unchecked local complaint would have been."

The only further remarks which I think it necessary to make on the present subject, though they are founded mainly on the use of mercury in syphilis, are also of important bearing on any proposed use of it in inflammations: first, that in cases of obstinate resistance to mercurialism, the resistance will often give way, if antimony during a day or two be also administered to the patient—a half-grain dose of tartar-emetic to begin with, and afterwards a few quarter-grain doses at eight-hour intervals; next, that long-continued mercurialism not only does not need to be assisted by other lowering measures, but almost always requires to be combined with generous diet, and not infrequently is attended with better results if the patient be treated simultaneously with doses of iron or quinine.

The effects of mercury on the mouth sometimes greatly exceed the intentions of the administrator; and it may therefore be convenient here to mention that for this action on the mouth chlorate of potash appears to be an antidote. Information on this subject, derived by M. Alfred Fournier[1] from the practice of M. Ricord, entirely confirms the statements previously made by Herpin and others. And, so far as my own trials of it have gone, I can speak to the same effect.

The convalescence of a part from inflammation—the process by which, when inflammation has begun to decline, the texture regains its old conformation and reverts to its old habits of life, is one in which nature, commonly speaking, acts without solicitation from art. Subsidence of excitement having once commenced, gradually but spontaneously the normal order of things appears again; the ulcerated substance, so far as it admits of reparation, is repaired by a continuous process of growth; the inflammatory effusion, so far as it has not become permanent tissue, is re-absorbed; the dilated blood-vessels return to their former dimensions. And while these actions of recovery move on in their due course, the best that we can do is to refrain from interfering with them.

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[1] Leçons sur le Chancre, professées par le Dr. Ricord, rédigées et publiées par Alfred Fournier: append. no. xii. The doses of chlorate of potash given were commonly ninety grains during the day; and it is very expressly stated, that, while the inflammation of the mouth is thus effectually cured, the therapeutical influence of the mercury is in no degree diminished.

But sometimes the process hangs fire: the ulcer, though no longer inflaming, yet does not actively repair itself; the granulations, though up to the skin-level, do not cover themselves with cuticle; the serous or fibrinous effusion, though free from pus, does not get removed; the mucous membrane, though scarcely oversensitive, does not stay its defluxion; the bloodvessels, though local hyperæmia be no longer demanded by local excitement, remain of augmented calibre. And under these circumstances we may do good by interference.

In a large proportion of such cases the defect of local action subsists through no fault of the part, but through some incompetency of the general system. Inordinate severity of the recent inflammation and fever, or over-vigorous depressive treatment, or previous unwholesome influences, or constitutional peculiarity, may have set the body into a state unfavorable for convalescence. The blood may be not nutritive enough for the purposes of reconstruction, or the nerve-power may be too reduced for the recovery of vascular tone. And under any such circumstances our best mode of assisting the local recovery is, *to amend the general health* in respect of whatever defect we discover there; perhaps by more animal food, perhaps by more alcoholic stimulants, perhaps by removal to country air, perhaps by quinine, perhaps by iron; during which treatment (particularly where the object is to recover local vascular tone) it may sometimes be desirable also, but with much caution, to use direct stimulants to the inactive part.

But sometimes it happens that local recovery is languid, in cases where the general health either has shown no defect or has apparently been relieved from any which existed. And it is especially in these cases that *local stimulating treatment* may be of essential service. Direct means for this end are very various, and of course require to be chosen with special reference to the part on which they are to act. Thus, where an ulcer or a superficial mucous membrane is concerned, we have recourse to the occasional touch of some chemical stimulant (of nitrate of silver or sulphate of copper, for instance, either solid or in strong solution, or of iodine paint), or to the continuous application of similar substances in extremely weak solution. Where skin-covered solids are to be treated, we try the occasional employment of the cold douche, or of friction or electricity, or the continual maintenance of pressure. Where serous or synovial sacs are to be dealt with, we use such vesicants or strong irritants, as, when applied to the covering skin, will extend their stimulation to the deeper texture. And, among the cases referred to, there are some where the local treatment is often of very marked advantage; as those cases of serous and synovial dropsy, and those cases of indolent infiltration of glands, where blistering can most properly be used; and those of chronic vascular congestion for which the douche is more specially suitable.

It will be observed that some of the agencies here mentioned have already been referred to, as occasionally useful in other circumstances; namely, not when all inflammatory excitement has passed away, but even, under peculiar conditions, during a certain amount of chronic excitement; and for the immediate purpose of converting that chronic excitement into transient acute inflammation. Those objects are professedly different from the object here under discussion; but it is not always easy to separate the two classes of cases, which here for convenience have been distinguished; nor can it confidently be said that the respective methods of treatment differ, except in degree, from each other.

It also deserves notice that there are textures, which, if after inflammation they require to be stimulated in their actions of repair, may have specific stimulants conveyed to them through the blood. Habitually, in the treatment of pulmonary and urinary catarrhs, the affected mucous membrane is in this way stimulated by some resinous or balsamic drug taken into the stomach; and occasionally, in well-selected cases and with extreme caution, the spinal cord may be thus affected by strychnine. It scarcely needs to be said that, in every case where question arises of stimulating an important organ which has been inflamed, full regard must be had to the danger that undue local action may thus again be excited. More than ordinary care must be used, both as to the local admissibility of stimulation, and as to the particular stimulus which may most fitly be employed; and in proportion as the case is critical, the practitioner will scrupulously consider whether the desired end can be attained by means less liable to mischance.

B. CAUTIONS AS TO THE APPLICATION OF ANTIPHLOGISTIC TREATMENT.

In discussing hitherto the various means by which inflammation may be treated, the writer (in accordance with the intention of the present essay) has of necessity done so in very general terms. Also he has rather sought to show what indications those several means are capable of fulfilling, and on what principles they ac-

cordingly must be used, than pretended to arrange all possible cases of inflammation under different heads with an appropriate system of treatment for each. A more detailed exposition of the subject, and a more clinical method of considering it, have alike been thought unsuitable to the present occasion. Perhaps therefore it may be well to remind the student that general principles will be valueless to him for practical work unless they be applied with thorough attention to detail. Practically to recognize what distinctive treatment is wanted in each individual case, and practically to estimate with what quantity of such treatment the want can sufficiently be met, these, the hourly recurring problems of practice, can only be solved by the man who minutely studies the case which is before him, and intelligently compares it with other like and unlike cases previously also studied with minuteness. No more than the galvanic battery can produce its results without the wires which complete its circle, can the great truths of pathology and therapeutics conduce to the successful treatment of individual cases of disease, except through the medium of observant, discriminative, skilled application. Fully to exhibit the art of this application is the business of the clinical teacher, and his function cannot be imitated with success in any printed system of surgery. Moreover, as regards the treatment of inflammation, whatsoever is distinctive in the requirements of different organs when they are inflamed, and whatsoever is distinctive in the requirements of different varieties of inflammation, will be discussed in special succeeding articles, and are therefore no part of the present writer's subject. Accordingly, I will attempt nothing further, before closing this section of my essay, than to convey some few cautions (still of a general nature, though from a more bedside point of view than I have yet taken) as to the spirit in which antiphlogistic treatment must be applied; not pretending to direct the student as to the circumstantial treatment of individual cases, but rather seeking to deter him from too hasty conclusions as to the facility of treating inflammation from the basis of general formulæ.

Inflammation, seen at its onset, commencing violently, exciting general vascular sympathy, and affecting some important part in a person otherwise sound and vigorous, may, in the absence of qualifying circumstances, be regarded as the type of cases for which lowering treatment is appropriate. Where the enumerated conditions are reversed, or in certain respects qualified by other conditions, such treatment ceases to be admissible.

In proportion as the patient's age, mode of life, previous or present disease, or other circumstances, render him peculiarly liable to depression, general bleeding, antimony, and vigorous purging fall from our list of applicable means; giving place (even though the inflammation be acute and important) to local agencies, repressive or derivative, and to moderate febrifuge treatment. In proportion as the inflammation is no longer commencing—still more where it has become chronic, or has established suppuration, lowering measures are sure to be hurtful. Where the inflammation is in its kind ulcerative or gangrenous, lowering treatment is almost absolutely contra-indicated. Where the inflammation depends on any specific dyscrasia, lowering treatment can scarcely ever be advantageous, nor perhaps generally can be harmless. Where the inflammation is produced by a morbid poison, very moderate febrifuge treatment is commonly the utmost that can be adopted.

Moreover, the amount of lowering treatment which the general system can with impunity bear, is not the only measure of the vigor with which such treatment ought to be employed. There are circumstances—especially those of mechanical and chemical injury—under which a certain quantity of inflammation is quite inevitable; and where to treat the inflammation without remembering the magnitude of its cause would be a fatal error of practice. When, for instance, with a given smash of limb, we determine not to amputate, but to rely on the reparative powers of the patient, we know that the comminuted bone, the torn integuments, the pounded muscle, can only recover by passing through a series of changes which begin with acute inflammation; that to prevent inflammation (were it possible) would be only to retard repair; and that our sole business with the inflammation is to moderate whatever excess it may have beyond that which we recognize as directly accounted for by the lesion. So again, when we operate for the extraction of cataract, we do not expect that the cornea, which we have cut in half its circumference, will remain, like the cornea of a dead body, without signs of having experienced injury; we know that the line of incision, and the ministerial blood-vessels of the conjunctiva, will presently get an aspect very different from that of health; but if, with bleeding and antimony, we could cause these phenomena not to develop themselves we should but hinder the process of healing which they essentially indicate. And it deserves very particular notice, that where, in consequence of injury, the inflammatory phenomena tend to more than ordinary local diffusion, or involve more than ordinary

destruction of tissue, this excess of local irritability is not amenable to treatment of a generally depressing kind.

Further, it is important to recognize that inflammation, even of considerable activity, may coexist with states of weakness and exhaustion which require to be treated on a system the very reverse of depressive. Often (as has been explained in discussing the causes of inflammation) defective nourishment of the body reduces various textures to a state in which, with little or no discoverable exterior cause, they begin to inflame, and continue ulcerating, sloughing, or suppurating, till generous diet restores the proper richness of the blood. Practice among the poorer classes of society is constantly showing us inflammations of this kind, veiled under a great variety of names, but as essentially starvation-phenomena as were those memorable ulcers of the cornea which Magendie produced in dogs by depriving them of nitrogenous diet. And although residence in the foul atmosphere of overcrowded and ill-cleansed tenements, irritation from bodily dirt and vermin, and exposure to cold, to violence, or to infection, are influences which, in the cases referred to, may primarily or secondarily modify the starvation-phenomena, and render necessary some adjuvant measures of treatment, an indispensable condition of recovery is that food be liberally supplied. Also during the repair of severe wounds, accidental or surgical, it often happens (even with persons of apparent health, though commonly where there is marked feebleness of pulse) that first a stand-still of the reparative process, and then some re-ulceration of the granulated part, give evidence of a relatively insufficient diet; and that, in order to prevent the wound from converting itself into an irritable sore, we must give more food, or perhaps especially more wine, or beer, or brandy, to our patient. And it is not only in obvious dependence on defective diet, or during the repair of exhaustive injuries, that we find this kind of necessity arising. For inflammation also associates itself (particularly in the form of irritable ulcer, and of subacute mucous catarrh) with states of depression which especially belong to urban life, with its impure atmosphere, with its over-work and anxiety, with its absence of beautiful objects, with its dulness of physical being. As regards the textural conditions which under these circumstances develop or maintain inflammation, nothing definite is known; but it may well be, that they are in close affinity to those of defective nutrition; and practically we see that the inflammation yields to tonic and stimulant treatment. Quinine is here often of very marked advantage.

It has already been said that the inflammations which are symptomatic of morbid poisons scarcely ever require more than the most moderate antiphlogistic treatment. Often they do not require more than the gentlest local treatment of this description; and in a large proportion of instances they require (or, more correctly speaking, the general state of the patient requires) that stimulants should be more or less liberally given. Not to dwell on such inflammations as lie outside the limit of surgical practice—such inflammations as those which occur in scarlatina, in typhoid fever, and in typhus—we may here more properly refer to the facts of erysipelas; in which disease it scarcely ever happens but that from an early period we are aware of imperfect vigor, often of considerable debility, sometimes of alarming exhaustion, in our patient; whose stomach, moreover, is commonly intolerant of solid food, and whose chance of living through the inevitable duration of his fever is then altogether dependent on the use of alcoholic stimulants. The very dangerous infection which is produced by inoculation with some cadaveric matters (apparently with certain inflammatory products at early periods after death) has close affinity to erysipelas; and a careful perusal of the published fatal cases of this disease leads the reader to suspect that an injudicious employment of depressing treatment must often greatly have conduced to render recovery impossible.[1] The subacute inflammations which arise from constitutional syphilis (especially those which involve ulceration) invariably become worse under lowering treatment; and where mercurial courses are employed in dealing with these inflammations, it becomes of paramount importance that the patient should have a generous diet, and sometimes that he should further be protected by the concurrent use of quinine or of iron.

Between cases which urgently require lowering treatment and cases which urgently require tonic and stimulant treatment, there are, of course, innumerable gradations. And the student must not suppose that the one line of treatment is the necessary alternative to the other. We may not bleed or antimonialize our patient, and yet not give him brandy or quinine. In an immense majority of cases neither course is necessary; the inflammation not justifying the first, nor concurrent debility the second; so that, as regards these alternatives, nature may be left to her own unassisted working. For here, as everywhere else, over-doctoring is an evil. Strong measures are not

[1] See the late Mr. Travers's Inquiry concerning Constitutional Irritation.

for trifling purposes; nor ought treatment at all to be used, except where treatment is necessary. In medicine, as in ordinary life, it is the great test of common sense that a man seeks, and it is the great reward of observant experience that he learns, to make his *means proportionate to his ends*. The over-doing of treatment, in comparison with the results which are to be attained, is an evil especially to be guarded against by those who begin therapeutics as an application of general principles, and it is therefore here particularly adverted to; and moderation, as needs hardly be said, is all the more necessary in cases where possibly the line of treatment may be wrongly chosen.

Most of all, before proceeding to the adoption of measures which depress the general health, the surgeon should have a very definite notion of the object which he means to accomplish, and should be sure that this object (if he can attain it) is worth the sacrifice. Even for the certainty of conquering some relatively unimportant local ailment, he would not hastily resolve to submit the sufferer to months of painful or enfeebling treatment. Still less will he be disposed to try such an experiment, even with his patient's sight or hearing at stake, when he knows (as, in respect of chronic inflammation and results of inflammation, he well may know) that almost inevitably it will be a failure. And as the case becomes more important to life, more and more he will remember that lowering treatment, if unnecessary, is dangerous. For every inflammatory fever, in proportion to its intensity and duration, is necessarily followed by exhaustion; and every inflammation, in proportion to its magnitude, depends on vital power for convalescence; and he who, without reference to these facts, needlessly depletes and lowers his patient even during the height of inflammation, much more he who does so during secondary conditions of the disease, will often contribute to render exhaustion deadly, or textural repair impossible.

Nor is it only depressive treatment which may be overdone. Indeed, of late years, fashion has set in the other direction; and perhaps not a little harm has come from misapplied alcoholization of the sick. True, that the cases in which life is saved even during inflammation by the judicious use of alcoholic stimulants are infinitely more numerous than those where it is saved by bleeding; and that the use of such stimulants, in certain cases of inflammation with debility, is among the most important resources of medicine. But the student must learn not to abuse this great medicinal agent; not to prescribe it, as a thing of routine, in all cases of inflammation bearing a certain name; but always to give or withhold, and (if giving) always to proportion it, according to the special requirements of the individual case. For there may be death in the practices of van Dunk as well as under the prescriptions of Sangrado. And medical advice will be but a sham if the treatment which it directs is to be indiscriminate.

ON HECTIC AND TRAUMATIC FEVER,

AND

ON THE TREATMENT OF CASES AFTER OPERATION.

By John Croft, Esq.[1]

Hectic Fever.

Derivation and Definition.—The word "hectic" owes its origin to the Greek adjective ἑκτικός, formed by the addition of the termination -ικος to the verbal adjective ἑκτός derived from ἔχω. The substantive ἕξις, derived from ἔχω, is commonly translated "habit;" but it expresses rather a permanent or abiding state; ἑκτικός, therefore, denotes something habitual, or rather something connected with a permanent or abiding state. Thus "hectic" in conjunction with the word "fever," serves to designate a permanent or abiding state of fever.

[1] This article has been, upon careful revision by Dr. William Hunt, found to need no addition or correction.

Any enduring local disease, which provokes an habitual state of febrility, or causes greater expense of the nutritious elements of the blood than can be maintained by the system, will give rise to the hectic state. The condition of the system produced by the sapping influence of profuse protracted suppuration is the most illustrative, and the one most frequently seen by surgeons. It is far from being the only cause; but so commonly is the state the result of suppuration, that by some it is frequently denominated the "suppurative fever."

Symptoms.—The first symptoms of hectic creep upon the patient insidiously. He begins to lose flesh. The pulse becomes variable in frequency and force, quickening on the least exertion or emotion. The skin is dry during the day, and towards evening it becomes drier and hotter; and the patient complains sometimes, but in my experience very rarely, of the subjective sensation of chilliness. The face becomes a little flushed, and the palms of the hands and soles of the feet feel dry and burning. If the patient falls asleep in this state, when he awakes he finds that he has been sweating, and the latter is out of all proportion to the previous chilliness and dry heat. He is able to sleep tolerably well during the night, and in the morning there is some remission of the symptoms. His appetite is but little altered, and in the intervals between the exacerbations the tongue remains clean, indeed morbidly red and clean and smooth. In this early stage there is generally a tendency to constipation of the bowels, and in the intervals between the sweatings the urine remains clear, though not abundant. In the second degree, the emaciation is more noticeable. The evening exacerbations and the morning remissions are more than ever characteristic of the state of the system. The pulse daily loses power, and increases in frequency. The tongue is smooth and glazed and morbidly clean. At the same time the patient is anxious for food, and often takes it with a relish. He sleeps tolerably well during the night, though the apprehension of the profuse sweatings may make him dread falling asleep. At this stage the bowels are often loose, and the urine becomes scanty, and deposits on cooling. In the evening there is exacerbation of the symptoms, during which the skin becomes hot and dry, the pulse quickens, and the temperature of the blood runs up as in the first stage of an ague, but the sufferer rarely complains of the subjective sensation of chilliness. During the night the temperature slowly declines, and towards early morning, when the sufferer, perhaps, has fallen asleep, a most profuse sweat bedews the skin and drenches his clothes. It is out of all proportion to the previous febrility and chilliness.[1] Whilst the temperature is rising through what is called the cold stage, the patient complains, in well-marked cases, of the burning sensation in the palms of his hands and soles of his feet, and the cheeks exhibit the florid circumscribed suffusion which is called the "hectic flush." After the sweatings the urine will be found to contain increased quantities of urea, chloride of sodium, sulphuric acid and water. The chills and sweats of different degrees may occur more than once in the twenty-four hours, but more particularly occur in the evening towards five o'clock. Meanwhile the patient's intellect remains quite unimpaired; indeed, sometimes the mind seems preternaturally clear and calm. In the third degree we find the patient suffering from the combined influence of the local disease and the colliquative effect of the exhaustive sweatings. The pulse becomes more and more feeble and rapid. The tongue, though it remains moist in the absence of febrility, becomes sore and covered with aphthous spots. The appetite begins to fail, and to be capricious. The skin, in the intervals between the sweats, is dry and harsh from branny scales. Œdematous swelling appears about the ankles and feet. The motions are frequently loose, and, as dissolution is approached, are passed involuntarily. The urine is more scanty and high-colored and offensive. Chills and sweats succeed each other as before, but at shorter intervals; and the sweatings are so profuse and exhausting as to be called colliquative. Still the nervous system remains exempt from participation in the general wreck. The mind is perfectly clear, and in the intervals between the paroxysms the sufferer obtains a tolerable amount of sleep. The emaciation proceeds to an extreme degree, and probably bed-sores are added to the list of deleterious agents. Finally, the patient becomes unable to take nourishment of

[1] The thermographs, Nos. 7, 8, 9, pages 135, 136, 137, are good examples of hectic. Each shows continued or renewed febrility. In each the evening elevations and morning remissions were subject to many interruptions, the causes of which were not always quite obvious. For the most part the irregularity was connected with either obstructed discharge, or the formation of fresh collections of pus. A temperature above 102° F. is exceptional.

In No. 7 the rapid fall of temperature on the evening of the 27th day, and the equally rapid rise during the night, were, no doubt, connected with the formation of the abscesses in the kidneys.

any sort, and he subsides into a state of unconsciousness, which is the sure precursor of approaching dissolution. The pulse and respiration become fainter and feebler, and so gradually and gently does death take place that a bystander could scarcely tell when life has ceased.

The duration of hectic depends very much upon the nature and extent of the local disease. If a case of very extensive suppuration were allowed to progress unchecked in any way, dissolution would speedily be the result; but when the local disease proceeds but slowly, as in morbus coxarius, the course of the hectic may be extremely protracted.

The symptoms of hectic, so long as the primary cause continues uncomplicated with any other, are subject to but little variety. The pulse is at all times frequent and weak; the chills, exertion, and mental emotion only serve to increase the rapidity, or render it flickering, for the time. Towards the evening exacerbation, it will always be found getting more rapid than it was during the morning remission. When the tongue is otherwise than smooth, clean, and glistening, the cause for the different appearance will be found to be due, perhaps to some irregularity in the administration of nutriments, to the occurrence of an exacerbation, or the imminence of some complication. Constipation of the bowels is of frequent occurrence in the course of hectic, and probably this state is owing mainly to the rapid reabsorption of the intestinal secretions. In the last stages of hectic, diarrhœa is commonly met with, and in the absence of tubercular disease may be attributed to the same cause as the colliquative sweatings. The chills and sweats which have been mentioned as constant accompaniments of hectic range in degree from the mere sensation of slight chilliness to paroxysms which seem to threaten the extinction of the little power remaining to the sufferer. The phenomena of a well-defined paroxysm in hectic would, if produced in the direction of intensity, be quite similar to the shivering fits of ague, pyrexia, or pyæmia. There is the same cold stage, during which the temperature, notwithstanding the subjective sensation of cold, is steadily rising; the same hot stage at which the temperature has reached its height; and the same sweating stage, through which the temperature declines, and the urine is relieved of the superabundance of urea, chloride of sodium, and sulphuric acid which had been collecting during the preceding stages. Hectic, however, should never be confounded with any of the above affections, as in every other respect, etiological and symptomatic, hectic widely differs from any of them. The only instance in which it becomes very difficult to distinguish the rigors of hectic from those of pyæmia is in the supervention of pyæmia upon hectic itself. The remarkable freedom from head-symptoms in hectic is a circumstance which should not be overlooked in any review of the phenomena of the affection. The intellect remains clear and bright from first to last. There is no infection of the blood in hectic, as in fevers properly so called; and it is only when hectic becomes complicated with pyæmia, erysipelas, or other accidental disease, that the brain gives occasional manifestations of functional disturbance and malaise.

Etiology.—Any enduring local disease which provokes an habitual state of febrility, or causes greater expense of the nutritious elements of the blood than can be maintained by the system, will give rise to hectic. The causes, then, must be various; they may be divided into two groups: in the first we place any severe enduring local disease affecting an organ of the body; and in the second, protracted diseases of a non-organic part of the body. In the first of these groups we find certain diseases of the stomach and mesenteric glands, phthisis, empyema, diabetes, abscess in the liver, disorganization of the kidney from calculous disease, tumors of the uterus, ovarian disease, disease of bladder and kidney consequent upon stricture of the urethra or calculous disease, etc. Out of the second group the surgeon derives the greater number of cases of hectic which come under his care. In this group are classed diseases of the joints and bones attended with continued or frequently renewed febrility or profuse suppuration; psoas, or lumbar abscess; extensive suppuration from injured parts, as compound fractures and lacerated and contused wounds; and any local disease which in the same manner is calculated to sap away the powers of the patient.

Pathology.—Hectic fever does not arise from the introduction or absorption of any foreign element or *materies morbi* into the blood, as is the case in contagious and specific fevers, such as typhus, typhoid, and scarlet fevers, smallpox, etc.; and it does not consist of the systemic participation in a local inflammation, as in inflammatory fever; but hectic arises when a local disease, as chronic joint disease, maintains an habitual state of febrility or is attended with renewed teasing through short attacks; or when the local disorder (as in suppurations, etc.) is the seat of an outfall from the system of the albuminous or nitrogenous elements of the blood, in quantities exhaustive of the powers of the sufferer. By this theory of the pathology of hectic, it is easy to explain the intrinsic phenomena of the affection; the loss of

weight, the emaciation, the state of the excretions, and the freedom from head-symptoms. When we consider the nature of the local discharge, and the metamorphosis of tissue, and consequent enormous tissue-waste which must take place during the exacerbations of the fever, we need not wonder at the rapid loss of weight, the rate at which the emaciation proceeds, and the undue quantities of urea and sulphuric acid which appear in the urine. At the same time, the immunity from head-symptoms is to be attributed to the comparative freedom of the circulation from the presence of any of the *effete* products of the said metamorphosis. The evening exacerbations,[1] which are commonly observed in the fevers as well as in hectic, must have their explanation in common with the like phenomena in those fevers; and probably their explanation is involved in the yet hypothetical cyclical changes of the tissues of the body. The chilliness accompanying the exacerbations in hectic is to be looked upon rather as a phenomenon of the exacerbations themselves, than as a symptom proper to the hectic. Without augmentation of the temperature of the blood it does not occur; and it is more or less marked in proportion to the height the temperature reaches, and the rapidity of the augmentation. It would appear to be entirely a subjective phenomenon, and produced by the state of the peripheral nerves and capillary vessels, which transmit to the sensorium the comparative condition of the peripheral parts. Hectic, at one time, was imputed to the absorption of pus into the circulation; but so well is pyæmia understood at the present day, and so fully will it be described in the essay devoted to it, that we need not take up space here to adduce the many conclusive arguments against there being any kind of relation between the two affections.

Treatment.—The treatment consists in the cure of the exciting cause, or its removal. If the local cause is such that its cure or removal is impracticable (as in certain organic diseases, and psoas or lumbar abscess), then the treatment can only consist of general palliative measures. But if the local cause can be removed, the removal should be effected immediately. It is evident that the hectic will not subside so long as the local cause shall exist. Thus, to mention one or two instances by way of illustration, if a joint is undergoing disorganization from the presence of a sequestrum of bone, that sequestrum should be removed by operation; or, if the hectic is produced by carious disease of the articular ends of the bones, the joint itself should be excised; but if the limb be the seat of some incurable disease, such as disorganized joint from traumatic inflammation, or extensive suppuration after contused and lacerated wound, the limb should be amputated. Before, however, such an important step is decided upon, the surgeon should have satisfied himself that no alternative is left him, and that he has exhausted all the resources of the healing art. Great judgment should be exercised in the discrimination of the time for resorting to such an operation as amputation; for although patients previously in an extremely exhausted condition have often rapidly recovered after the removal of the local disease, yet many have been temporized with for so long, that neither operation nor any future treatment have availed to save them from death.

The general treatment of hectic must be principally directed to maintaining the strength of the patient. Nourishment must be freely though carefully given, regard being had to the periodicity of the exacerbations and to the diarrhœa. Patients should never be allowed to go for any length of time without nutriment, and the latter should never be given in large quantities at once. Meat, concentrated essence of meat, eggs, isinglass, and other nitrogenous substances, should be the articles of diet chiefly preferred. Stimulants should be given judiciously. They are not so urgently required in hectic as in some other affections. Enough should be given to maintain the patient's circulation, but they should never be deemed of more importance than nutriment. The evening exacerbations and sweats should be prevented, if possible, by doses of quinine, sulphuric acid, and iron, well timed before the hour at which they may be expected to recur. These remedies are most useful in checking the exacerbations and sweats, and therefore we recommend them; but beyond these, only occasional doses of medicine should be employed to control diarrhœa or procure sleep. Pulv. kino comp. will be found the most useful in the diarrhœa, as it tends to check the sweating as well as the discharge from the bowels. Sulphuric acid alone is powerless to check the diarrhœa. Diarrhœa, from tuberculous disease or from errors in diet, must be combated by the remedies ordinarily in use for such affections. In all cases in which hectic is likely to last for any length of time, we strongly recommend that the sufferer should be early put upon a water-bed, and that every device for preventing bed-sores should be resorted

[1] All observers of the diurnal temperature of the body agree in stating that one maximum temperature takes place about 5 P. M.

to. Finally, with regard to those instances in which amputation seems to be the only remaining alternative, we would impress upon the Surgeon the impropriety of wasting valuable time in vain attempts to stave off the evil day. "True clemency does not consist so much in delaying strong and vigorous measures, as in boldly deciding to put them in execution as soon as they are indicated."

References: Hunter on Inflammation; Dr. Parkes's Gulstonian Lectures on Pyrexia, Med. Times and Gaz., vol. x.; Dr. Sidney Ringer on "The Connection between the Heat of the Body and the excreted amounts of Urea, Chloride of Sodium, and Urinary Water, during a fit of Ague," Med. Chir. Trans., vol. xlii.; and "Cycles in Disease and Health," ib. vol. xlv.; "On Inflammation," Mr. Simon, System of Surgery, supra.

Traumatic Fever.

Definition.—Traumatic Fever is that species of inflammatory fever which is produced by the one constant cause implied in its particular denomination: in other words, the febrile condition which, as a general rule, rapidly follows the infliction of a wound of any magnitude, is called traumatic fever.

Symptoms.—As in inflammatory fever, so in traumatic, *pari passu* with the augmentation of the temperature locally, that is, at the seat of the wound, the temperature of the mass of the blood rises, and the phenomena of general febrility manifest themselves. Thus, the pulse becomes quick and perhaps sharp. The patient feels restless. The skin grows hot and is dry to the touch. The face is flushed. Thirst is complained of, and appetite declines. The tongue is foul and furred. The excretions are correspondingly altered in character; the urine is scanty, high-colored and saline, and it is said at the same time to become remarkable for the absence of its chlorides. The fæces are often retained, and when passed are dark-colored and offensive. Towards evening the temperature of the blood augments, and simultaneously the symptoms undergo some exacerbation. With the advance of these usual accompaniments of febrility the restlessness is apt to increase; and when the patient falls off to sleep, his rest is troubled and unrefreshing—in the more severe injuries the sensation of chilliness may occasionally be met with, but I have never found patients complain of it in my own experience.

Supposing the local inflammation to pursue a favorable course, the signs of general febrility commonly begin to decline about the third day, and have subsided altogether by the seventh day, unless some complication has occurred to produce a secondary state of febrility. Day by day the rapidity of the pulse declines, and becomes a better index to the power of the patient; the heat of skin subsides; the tongue cleans and becomes moist; the excreta acquire a more healthy character, while the restlessness subsides, and sleep is once more restorative.

The foregoing is the description of a well-marked uncomplicated case; but practically traumatic fever is subject to considerable variety, not only with regard to the degree and duration of its symptoms, but also with regard to result.

Duration, Degree, and Result.—First as concerns duration and degree. All observers agree in stating that most minor injuries and operations, under favorable circumstances, are not followed by any perceptible amount of systemic febrility; such injuries as simple fractures and dislocations—and such operations as amputations of fingers or toes, excision of eye, or cancer of lip, circumcision and the like; on the other hand, though the larger operations and injuries lead to more or less fever, yet the magnitude of either operation or injury does not, as a rule, determine the amount of febrility; nor is the latter decided by the part affected—the 4th case, in the table on p. 138, supports the statement that the magnitude of an operation is not decisive of the intensity of wound fever.

These statements accord with Billroth's writings on the subject. That author mentions C. 40.5° (104.9° F.) as the maximum temperature reached in the cases he observed. F. 104° (C. 40°) was the maximum noted in my own cases. The febrility commonly commences very quickly, within a few hours after the operation or injury, blending more or less with the reaction from shock, where the latter has been produced. In some cases the febrility does not become manifest until the second day, or even later—after the less important operations or accidents, it may end a few hours from its commencement, but in most cases of any magnitude, the feverishness lasts from two to five days, in some as long as seven days; when it lasts more than seven days, the prolongation is generally due either to the traumatic merging into suppurative fever or to an inflammation consecutive and secondary to the first, and often there has not been any interval between the two. From the table on page 138, of 18 cases of large operations and extensive injuries of the limbs, it will be seen that in the first eight cases the highest temperature (as indicative of febrility) occurred on the second day, and that the mean duration

of the fever was four and a half days. In the five succeeding cases the maximum was not attained until the third day, and in each case some sort of complication happened. In the last five cases the fastigium was delayed until the fourth day, and with one exception complications also took place.

From these observations, which are very much in accordance with Billroth's numerous ones, it would appear that we may expect wound fever, under favorable circumstances, to decline on or after the second day.

A high degree of temperature on the first day (see case No. 1 in the table) does not necessarily imply a long duration of the fever. As I have already stated, I have never met with a case in which the febrility was ushered in by a rigor, though I have frequently found secondary or accidental fevers announced by chills and rigors.

My own observations support Billroth and others that hemorrhage, even when very considerable, only delays the rise of temperature. I have not found, as other observers state they have done, that the maximum temperature in this fever always occurs in the evening.

Billroth states that the duration of the fever, in his experience, is not influenced by primary union, and that age and constitution have no essential influence over the time the fever lasts. In the table are two cases, Nos. 17 and 18, which support the above named author's observation that suppuration does not affect the period of decline of febrility. Those cases recovered without the formation of any pus, yet the febrility lasted in each case as long as in several others in which suppuration took place.

The pulse almost always keeps pace with the temperature. It increases in frequency as the temperature rises, and declines in a similar way as the temperature subsides; when there is a want of harmony, it is generally owing to more or less loss of strength, or debility, on the part of the patient. In such cases morning and evening use of the thermometer is particularly desirable.

The condition of the urine in wound fever appears, from Müller's and Dr. Parkes's researches, to be much the same as in pyrexia generally.

The result of traumatic fever must necessarily be subject to a great variety of influences. It may end healthfully at any time from two to seven days; but, on the contrary, it may be subjected to the influence of some peculiarity in the condition of the patient, it may be succeeded by more or less violent secondary fevers, or become complicated by some accidental disorder. Should a patient remain feverish after the seventh or eighth day, or recommence to be feverish after he has once been free from that state, a secondary cause must be sought for. In by far the greater number of cases this cause will be discovered to be a local one. In the milder forms it may be due to the retention of clots, or serum, or foreign bodies in the wounds; or it may have proceeded from the extension of the inflammation to neighboring tissues, or be due to the disintegration of effused blood, to confined sloughs of fascia, or the formation of some deep-seated collection of pus; whilst in the more acute cases, the renewed febrility will be found to have arisen from correspondingly grave causes, such as erysipelas, tetanus, septic poisoning of the blood (septicæmia) by putrid fluid from the locality of the injury, from phagedæna, or from that scourge of some surgical wards, pyæmia. Thus it will be seen that the period of decline of the traumatic febrility is the time at which the patient is most exposed to secondary or accidental affections, such as those just mentioned; and this period, therefore, should be watched by the surgeon with undiminished vigilance and care. The thermographs, which are given in this essay, serve to illustrate this part of the subject.[1] No. 1 is from a case in which primary amputation was performed below the knee for injury. Febrility continued for some days after the fastigium (fourth day) of the wound fever, in consequence of the surface of the stump becoming sloughy. After the eleventh day, by which time the sloughs had separated, the temperature rapidly subsided to the normal degree. This man, however, became the subject of another and distinct fever from the eighteenth to the twenty-second day, when the temperature reached F. 100.2°. This was connected with the formation of an abscess above the knee.

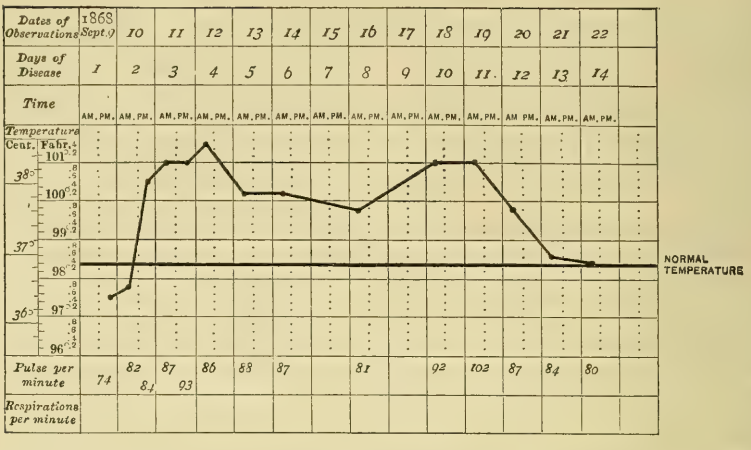
In No. 2 the temperature suddenly ran up to F. 100.9°, though it was known on the eighth day to have been F. 98.8°. Pus had formed at the seat of fracture. Soon after the wound had been reopened and the pus allowed free exit, febrility subsided and did not again occur.

In the 3d instance, that of a compound fracture of the tibia and fibula, the temperature remained high after the fourth day, being kept up by septicæmia, which began on that day.

In the 4th case, I had amputated above

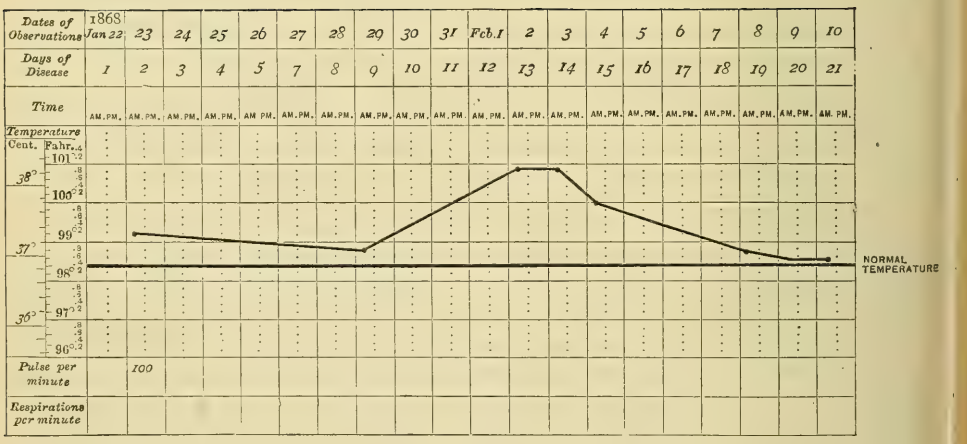
[1 The temperature-charts generally used in this country have the figures for the pulse on the lower margin, instead of parallel with those for the temperature. Thus the two records cross one another, instead of lying side by side across the paper. Both forms have their advantages.]

No. 1.



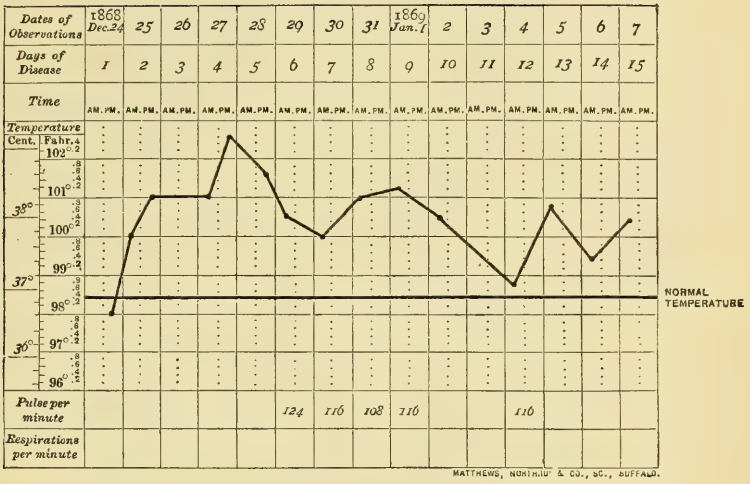
D. D., æt. 47. Primary amputation below the knee; cured. Surgeon, Mr. Clark.

No. 2.



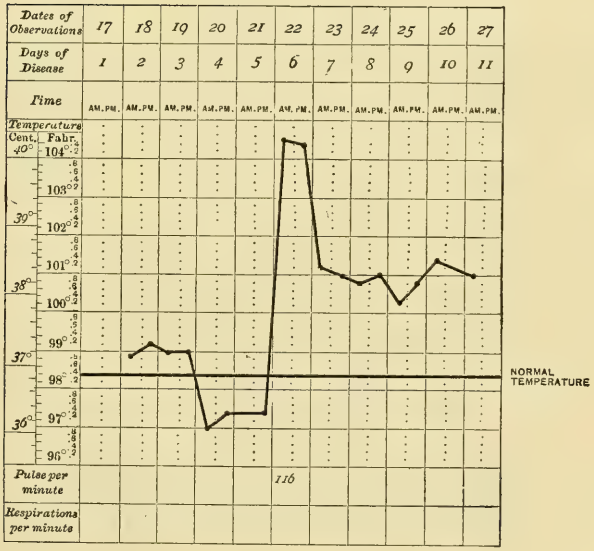
J. G., æt. 10. Compound fracture of tibia and fibula; cured. Surgeon, Mr. Clark.

No. 3.



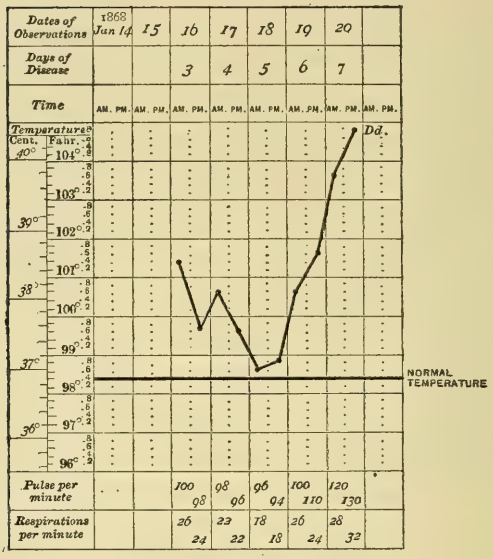
G. G., æt. 37. Compound comminuted fracture of tibia and fibula, with much contusion and laceration; cured. Surgeon, Mr. Solly.

No. 4.



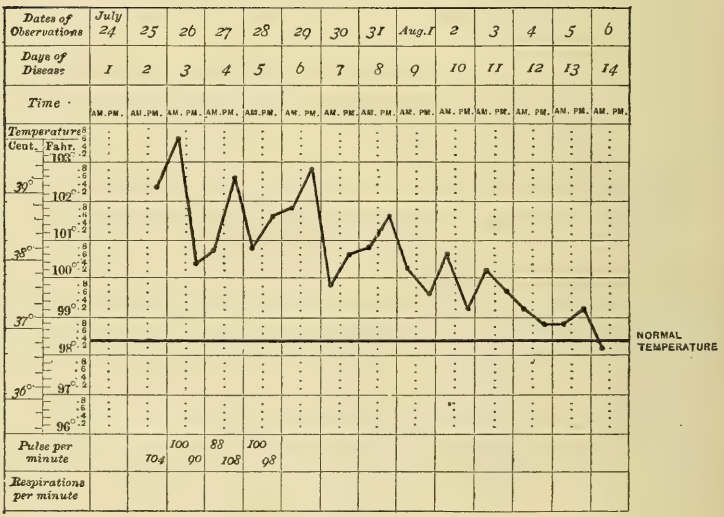
G. D., æt. 55. Amputation above wrist, for disease. Erysipelas. Cured. Surgeon, Mr. Croft.

No. 5.



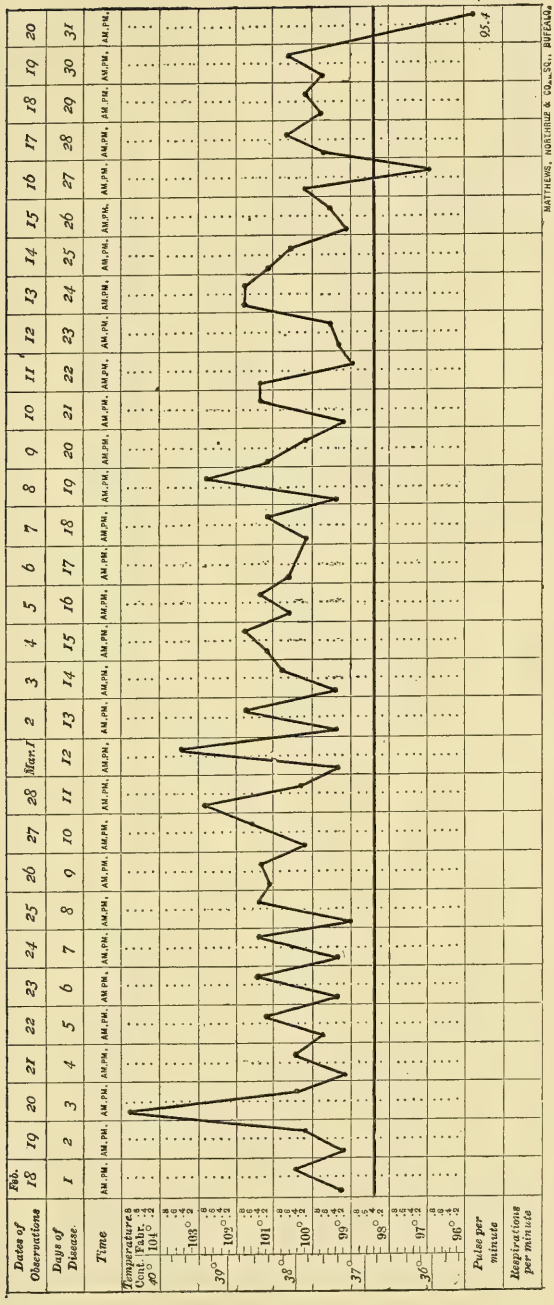
T. A., æt. 25. Spike-wound of hand. Tetanus. Died. Surgeon, Mr. Holmes.

No. 6.



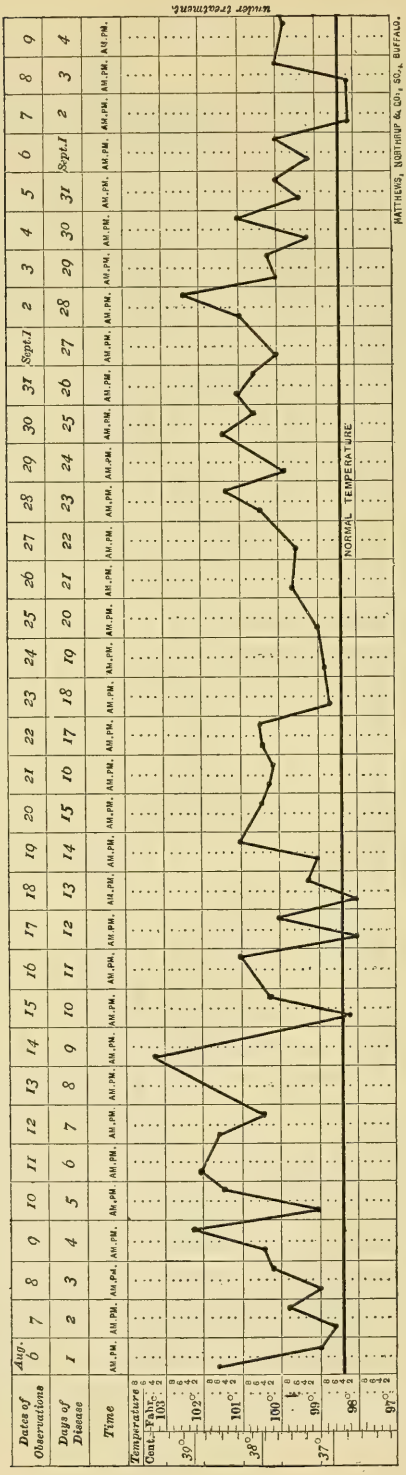
T. B., æt. 34. Gunshot-wound of hand. Trismus. Cured. Surgeon, Mr. Holmes.

No. 7.



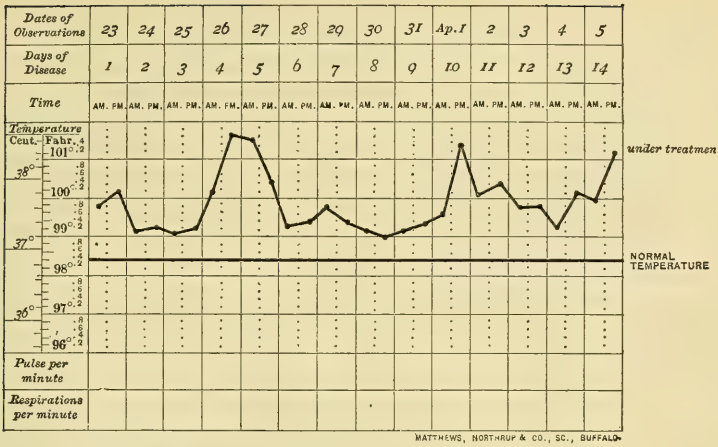
J. S., æt. 64 (or more). Suppuration in knee-joint. Abscesses in kidneys. Died. Surgeon, Mr. Solly.

No. 8.



H. S., æt. 40. Psoas Abscess. Surgeon, Mr. Clark.

No. 9.



S. H., æt. 21. Psoas Abscesses. Surgeon, Mr. Clark.

the wrist-joint for disease. The temperature was as low as F. 97.4° on the fourth day, but mounted up during the night, and the next morning stood at F. 104.5°, erysipelas appearing on the stump.

For No. 5 I am indebted to the kindness of the editor. It will be seen that the wound fever had subsided on the fifth day, but the temperature began to rise again on the sixth, when tetanus showed itself and proved rapidly fatal. No. 6 was also one of Mr. Holmes's cases. Trismus declared itself on the third day, and maintained the temperature above the normal for some days. Trismus and temperature together gradually declined. It must not be overlooked that renewed or continued febrility may be due to inflammation of organs or tissues contiguous to the seat of injury or operation, as pleuritis after fractured rib, peritonitis after herniotomy or wound of the abdomen, meningitis after fracture of the skull, and so on. Waxy disease of the liver, spleen, or kidneys, and fatty changes in the liver, or Bright's disease, do not appear to exercise any special influence over the wound fever, though operations and severe injuries in patients who are already suffering from the two last named diseases, as a rule, do badly.

The pathology of wound fever is that of "inflammatory fever," and I cannot do better than refer to Mr. Simon's article on the subject. He states that "inflammatory fever" is a total bodily infection wrought by materials from the inflamed part. M. Billroth says that "traumatic fever, like all inflammatory fevers, depends essentially on a state of intoxication of the blood, and may be provoked by diverse substances which proceed from the focus of inflammation into the circulation."

Treatment.—If the surgeon has already made himself thoroughly acquainted with the principles on which inflammatory fever and local inflammation should be treated, by careful study of Mr. Simon's essay, he will have no difficulty in comprehending how cases of traumatic fever should be managed. In the same way that local inflammation and inflammatory fever stand to each other in the relation of cause and effect, so wounds and traumatic fever depend the one upon the other. The subject of treatment, therefore, is naturally resolved into local and general. Presuming that the wound has already given rise to general febrility, the first remedial step should be a local one —viz., to place the wounded part in that position which will simultaneously control the circulation to and from the seat of injury, favor the drainage from the wound (if there is any), and be most agreeable to the patient. Cold is the next local remedy which should be employed. Cold, judiciously applied, is a most powerful agent in restricting the degree and extent of local inflammation by the abstraction of heat, and it follows that it must necessarily exercise, through its local agency, a certain measure of influence over the intensity of the symptoms of general febrility; hence much stress is laid upon its use. Ice, inclosed in water-proof bags, should be spread over the wound and its neighborhood; and a special attendant should be employed to see that the application is never intermitted, even for a minute. If ice is not to be had, cloths wetted with very cold water should be kept constantly spread over and around the wound, or glass vessels containing cold water may be kept applied in a similar way. A comprehensive account of

No.	Surgeon.	Operation or Injury.	Age.	Duration of Fever.	Day of Maximum Temperature.	Maximum Temperature.	Pulse.	Result.	
1	Mr. Solly	Amputation above elbow for disease of elbow-joint	16 years	3 days	2d day A. M.	F. 104. C. 40	...	cured	No complication
2	Mr. Croft	Operation exploratory for necrosis of humerus	15 years	5 days	2d day A. M.	F. 102.4 C. 39.1	128	cured	No complication
3	Mr. Clark	Ovariotomy, extensive adhesions torn through	33 years	3 days	2d day P. M.	F. 101.8 C. 38.7½	...	cured	No complication
4	Mr. Clark	Amputation at hip-joint for tumor of femur	15 years	4 days	2d day P. M.	F. 101.4 C. 38.5¼	144	cured	No complication
5	Mr. Clark	Lacerated and contused wounds of forearm	13 years	4 days	2d day A. M.	F. 101.3 C. 38.4¾	...	cured	No complication
6	Mr. Simon	Arm torn off at shoulder-joint. Trimming	14 years	6 days	2d day P. M.	F. 101.2 C. 38.4¼	110	cured	No complication
7	Mr. Croft	Excision of breast	52 years	7 days	2d day P. M.	F. 100.3 C. 37.9	...	cured	Bleeding which required the wound to be opened
8	Mr. Croft	Amputation above wrist for disease of wrist-joint.	55 years	4 days	2d day P. M.	F. 99.1 C. 37.2½	...	cured	Secondary fever on sixth day, erysipelas
9	Mr. Holmes	Gunshot wound of hand, trismus	34 years	13 days	3d day A. M.	F. 103.6 C. 39.7½	100	cured	Trismus on third day
10	Mr. Holmes	Spike wound of hand, tetanus	25 years	5 days	3d day A. M.	F. 101.4 C. 38.5¼	100	died	Tetanus on third day
11	Mr. Holmes	Amputation below knee for disease of bones of foot	28 years	4 days	3d day P. M.	F. 101.3 C. 38.4¾	130	died	Sloughing, hemorrhage, pyæmia
12	Mr. Croft	Excision of breast	53 years	8 days	3d day A. M.	F. 100.8 C. 38.2	...	cured	Discharge collected
13	Mr. Croft	Amputation below knee for injuries	61 years	5 days	3d day A. M.	F. 102.4 C. 39.1	90	cured	Sloughing and excoriations from carbolic acid
14	Mr. Clark	Amputation below knee for injuries	47 years	14 days	4th day A. M.	F. 101.5 C. 38.5¾	86	cured	Sloughs and abscesses
15	Mr. Simon	Lacerated and contused wounds of upper arm	14 years	6 days	4th day P. M.	F. 101.4 C. 38.5¼	...	cured	Carbolized dressings taken off on third day
16	Mr. Solly	Compound comminuted fractures of tibia and fibula	37 years	12 days	4th day P. M.	F. 102.6 C. 39.2	...	cured	Septicæmia on fourth day
17	Mr. Croft	Compound comminuted fracture of tibia and fibula	38 years	6 days	4th day P. M.	F. 101 C. 38.3	...	cured	Carbolic acid treatment (Lister's)
18	Mr. Clark	Compound fracture of tibia and fibula	12 years	6 days	4th day A. M.	F. 100.6 C. 38.1	...	cured	Dry lint on wound

The above cases, with three exceptions, were in the wards of St. Thomas's Hospital. I was enabled to watch my colleagues' cases by their kind permission. With the exception of Mr. Holmes's cases, I am indebted for the temperatures, mainly, to the registrar, Mr. W. W. Wagstaffe.

the local treatment required by the various kinds of wounds is not within the province of this article, which only has to deal with the wound so far as the latter is connected with traumatic fevers; and for the various modes in which wounds and injuries are to be treated independently of traumatic fever, I must refer the reader to the essays on WOUNDS, FRACTURES, etc. The general treatment should be quite simple, so long as there is freedom from complication; rest, limited diet, and attention to the secretions, being all that is necessary. In the severer forms in robust persons, when the pulse is strong and full, or when inflammation of some vital organ contiguous to the injury is threatening, it may be necessary to employ febrifuge remedies, as topical bleeding, antimonials, or laxatives; but as a general rule, absolute rest, abstinence, and a purge in the case of constipation, are all that are required in addition to the local treatment. In aged subjects, and those who have suffered extensive injuries or operations, notwithstanding symptoms of febrility, the powers must be aided or maintained by stimulants; and to those who have been accustomed to much wine and beer, or to take opiates, sedatives should be administered unhesitatingly.

When the febrility has been *renewed* by any cause, local or general, the local and general treatment will require to be modified to meet the exigency of the particular case. If the wound has become the seat of fresh inflammation, it must be examined for retained foreign bodies, and provision should be made for the escape of clots, serum, sloughs, pent-up pus, etc. Foul discharges should be corrected by suitable disinfectants, as carbolized water, or the chlorinated washes. In the general treatment, care should be taken to correct any retention of the excreta, and complications, such as organic diseases, erysipelas, septicæmia, pyæmia, delirium tremens, or tetanus, must be met by suitable remedies.

References: Mr. Simon on Inflammation; Mr. Paget's Lecture on Treatment of Wounds; on Fever accompanying Surgical Affections, Dr. Billroth (Berlin: Hirschwald); or Abstract in Year-book of Sydenham Soc., 1862, and Pathologie chirurgicale générale; Observations on Fever accompanying Surgical Affections, by F. W. Gibson, M. D., Med. Chir. Review, No. LXXVII.

MANAGEMENT OF PATIENTS AFTER OPERATIONS.

Owing to the many beneficial modifications and improvements which have been effected during the last three hundred years in general as well as operative surgery, there is no branch of our art which has undergone more amelioration than that of the "Management of Patients after Operations." And we may felicitate ourselves all the more, that these changes, agreeably with all genuine progressive amendments, are in the direction of simplicity and soundness.

If we briefly delineate the state of things after a severe capital operation performed three hundred odd years ago, the student of the present day will then perceive how much room there was for improvement; and at the same time he will be better able to appreciate the changes which must have been accomplished ere we could have arrived at the simple and sound after-treatment of our own time. Take, for instance, amputation of the leg. The poor sufferer has had the soft parts of his limb severed to the bone by one deep circumcisive sweep of the knife, the bleeding vessels have been broadly seared with the actual cautery by no sparing hand; and, shocked and agonized as he is by these preliminary steps, there only remains to him the dismal certainty (should he recover the shock of the hemorrhage) that his poor burnt and painful stump must undergo all the tortures of casting off its charry sloughs through a tedious course of emplastrics and agglutinatives, caustics and repercussives, detersives and mundificatives, ere it can be pronounced to be, at its best, a tender cone of thin-skinned granulations.

On the contrary, at the present time, thanks to the numerous advances and discoveries which have accrued upon the extended use of the ligature (for which we are indebted to Ambrose Paré, A. D. 1535), and the subsequent development of the process of union by primary adhesion, we can now boast that our patients may contemplate operation without dread, may undergo its performance with the very minimum degree of shock, and may recover from it tranquilly, speedily, and almost painlessly. In order, however, to accomplish so much as this, many precautions and much care must be taken, both with respect to the wound and the patient; and these pains are required, not so much in elaborating and doing a great deal, as to keep at a distance all the evils and mischiefs which might interfere with the simple and natural process of repair We cannot impress it too strongly on the surgeon that, in his after-treatment of operations, his business should be to keep jealous guard over the simplicity of the reparative processes of nature. "And let it not be thought that thus limiting our office in the ordinary charge of patients after operations to the mere 'watch and guard' of natural processes, we diminish

or degrade the true value of our calling. The obstetrician has not done so in giving up all the 'meddlesome midwifery' of former times; and certainly that branch of our profession was never more honored or more useful than now, when, in all ordinary cases, it limits its duty to the superintendence of the sufficient work of nature. Similarly, surgeons may stand by and watch; content to shut out mischief (always a difficult task), well content if they can do that which is much more difficult —control the restlessness of popular or half-taught ignorance, which, in its audacity or its fright, would be forever busily trying to improve the perfect ways of nature. Both these are difficulties; but if we are ambitious of more, we find only too soon that, easy as the task may seem when all goes well, the utmost strain of all our knowledge and of all our mental power is not too much for the difficulties that may arise in an untoward case."[1]

After an operation, the first care of the surgeon should be to close the wound well. We presume that it will be his desire to get the wound healed as much as possible by primary union; but in the execution of this very proper design, the surgeon must at once make up his mind to be cautious and circumspect. If he attempts to obtain as much primary union as possible, without regard to the nature of the wound, he may not only in part fail, but probably will entail the sacrifice of immediate union through the whole extent of the wound, and therewith his first difficulty will have commenced.

In wounds of depth and intricacy, such as those made in the removal of exostoses, and some deeply attached tumors, and in wounds communicating with cavities, such as those after herniotomy, lithotomy, removing sequestra of bone, and those made by amputating through abscesses, and in similar wounds, it would be positively mischievous to close the wound entirely and attempt to procure primary union. The surgeon has the choice at first of securing complete primary union, or partial union, or of leaving the wound to heal by granulation: let him be discreet in choosing which degree he will attempt to achieve, for the future management of his patient will be very much simplified by his pursuing that course which will leave him nothing he may have to undo. Whilst on the subject of closing wounds, we will take leave to extend our remarks to a topic intimately connected with it, viz., securing the bleeding vessels. We strongly advise that all bleeding should be stopped before the wound is closed; and that, whether by acupressure, ligature or torsion, every bleeding orifice should be compressed, and the wound finally closed before the patient is removed from the operating table. There are some wounds in which, for a short time after operation, owing to faintness or shock, it must remain uncertain whether any more bleeding will occur; in such, of course, the wound must be allowed to remain open; but it should be closed as soon as possible after reaction has fairly passed its height. As a rule, to revisit and disturb patients some three or four hours after operation (as amputation) in order to close and dress the wound, is a practice as cruel as it is unnecessary. Attention to details such as these will diminish the risks of future difficulties more than some are inclined to admit.

In "dressing" the wound for the first time, or indeed at any time, the surgeon should think rather of how little than of how much he must take upon himself to do, and of how little he need interfere with the natural reparative processes.[1] Let him be content to put as little dressing about the wound as possible. He had better put nothing at all than too much, especially to wounds which must heal up from the bottom. If the sutures hold the edges of the wound accurately together, in the instances of those wounds which are to heal by primary union, any further means of contact should be rejected as unnecessary. Support should be given to the vicinity of any wounded part which may be subjected to movements tending to interfere with its perfect repose; for instance, after ovariotomy, resection of a joint or after amputation; but the bandaging and pillows must not be allowed in any way to obstruct drainage from the wound (if any be likely to occur), or prevent the preservation of perfect cleanliness. Perfect repose and perfect cleanliness are most absolutely necessary adjuncts to the local management; and if these are not preserved from the outset, all the care which has been bestowed on the starting of the case will have been thrown away. For the preservation of local repose, all unnecessary movement of the wounded part must be strictly prohibited; if our advice be followed with regard to simplicity in dressing the wound, the part need be but little disturbed on account of strapping, bandaging, and cleansing. Cleanliness throughout the local management cannot be too strongly insisted upon; it is not enough to remove dressings as they foul, and pools

[1] Paget, Address on Surgery, London, August, 1862.

[1] The subject of the "antiseptic treatment of wounds," were it one on which a majority of surgeons are agreed, is too important for only the brief reference of which this article would admit. (See Inflammation, Abscess.)

of discharge when they have collected; but the soiling of the dressings, and any collections, should be *prevented* by careful drainage from the wound and the liberal use of such antiseptics as vegetable charcoal, solutions of carbolic acid in water, Condy's solution, or the chlorinous washes. Local bathing should be employed whenever practicable, especially in perineal cases; and, in short, anything that can interfere with perfect cleanliness about the wound or the bed, or with free ventilation, which latter must ever be associated with cleanliness—should be most studiously avoided. With regard to the application of ice or cold, either should be avoided, on the principle of interfering with natural processes as little as possible, unless it be specially called for by traumatic fever or the threatening of recurrent hemorrhage. The latter may be expected to follow a sudden rise of temperature.

Sutures should not be removed in accordance with any fixed rule, but rather at discretion; so long as they are innocuous in the wound, and yet of service in keeping edges together, let them be retained, for they will serve for a short time longer instead of messy plaster.

The final removal of ligatures should generally be deferred until they have evidently loosened from their holds. In the rare instances when they remain fast on beyond the usual time, traction should be repeatedly applied until their hold has at last given way. Were ligatures always tied as tightly as they should be, accidents with them would happen even more rarely than they do.

Before leaving the subject of local management after operations, we must not omit to refer to the necessity for constant watchfulness to detect and promptly evacuate any deep-seated suppuration or secondary abscess, nor must we fail to remind the surgeon that it is his business to be ever on guard against the supervention of some secondary affection or complicative disorder.

In the general treatment, simplicity should be the one thing aimed at as much as it has been recommended in the local. The room, or portion of ward, in which the patient is to live should be kept scrupulously clean and ventilated. All unnecessary bedding and bed-furniture should be strictly prohibited. His bed should be so prepared with regard to its sheeting and covering that changes may be made without disturbing or removing the patient himself. In some operations, such as those for ovariotomy, lithotomy, herniotomy, etc., it is of the utmost importance to adopt some special plan for facilitating the changing of the bed linen, and indeed the body linen of the patient. His personal cleanliness should also be attended to with the most scrupulous care; his linen should be frequently changed, at least as frequently as he will bear the necessary moving and exertion; sponging and bathing ought to be copiously performed, not only for general, but also for local purposes, especially after such an operation as section of the perineum for extravasation of the urine. Excreta should be methodically carried away from the patient's room as soon as passed. His room should be kept well ventilated at all times; and when convalescent, he would benefit by being removed, if possible, to another room, or even to another part of the ward. With regard to diet, we would specially have the surgeon on his guard against falling into any extreme. It by no means follows as a matter of course, that because a patient has undergone an operation and has lost blood, more stimulants and more nourishment are to be added to his dietary; and, on the other hand, it would be as great an error suddenly to cut him down because he has just been relieved of some consuming disease, or because of some vague fear of "inflammation." The surgeon must not act by rule, but he must proportion the dietary to the present exigencies of the case. After by far the greater number of operations on the surface of the body or the extremities, the inclination of the patient may be trusted as a safe guide; he may be allowed to take solid and fluid nourishments as near in quantity and quality to those to which he has been accustomed, as his altered appetite will permit. Proportionate allowance must be made in case his appetite has been exceptionally indulged; and should he have been accustomed to take excessive quantities of stimulants up to the time of operation, the surgeon must be careful so to proportion the supply of the usual stimulants, that he shall neither suffer from their absence nor feel their presence. Occasionally it happens that amputation is performed in the midst of the course of hectic, and at a time when the sufferer is taking very large quantities of stimulants and nourishment; it would be highly injudicious in such a case to continue the stimulants at the previous rate, and it would be equally an error to withdraw them suddenly; they should be gradually diminished, commencing from the day after the operation. After operations involving peritoneal or mucous membranes to any extent, there is more reason for instituting rigid daily surveillance over the patient's dietary; for transgression beyond light, unstimulating, and nutritious articles of food and drink may prove of the gravest importance.

Besides the foregoing very important subjects—of cleanliness, ventilation, and

diet, which concern all operation-cases without exception—there are some special *symptoms* which occasionally arise as immediate consequences of the operation or of the action of the anæsthetic. The events which we most frequently meet with are shock or faintness, sickness from chloroform [or ether], retention of urine, and pain or restlessness.

Shock, purely the result of the mutilative part of an operation, is rarely, if ever seen at the present time, when the benefits of chloroform are so very generally made of avail. But there occasionally happens from the combined effects of operation, loss of blood, and chloroform, such a faintness, a *deliquium* so threatening, that the condition is quite as alarming as shock itself; and the worst of it is, that but little of the warning of its approach is noticed beforehand; the patient is almost suddenly found to be in this condition, and the first impression is that too much chloroform has been administered. The faintness, however, continues long after the chloroform has been discontinued, and reaction follows but slowly. In the treatment of this condition great caution should be observed, the impulse being to instantly begin an overflowing administration of brandy and stimulants. Stimulants must be given, and brandy is the one most to be preferred; but it should be given at intervals, regulated by the state of the pulse; as the effect of the preceding dose seems to subside, the next should be given, and so on, at gradually increasing intervals, until at last the signs of reaction have become steady and sure, when the remedy should be discontinued. The administration of nutriments may be recommended when reaction has set in, but they are worse than useless during the first period of the faintness; for their simultaneous ingestion with the brandy or stimulant most frequently provokes vomiting, and entails the awkward necessity of temporarily suspending the brandy.

For a further and exhaustive account of the particulars of shock, the student may refer to the essay on "COLLAPSE."

Continued sickness from the chloroform is another symptom, which may happen after operations; and when it does occur, it not only complicates or increases any faintness there may be, but it sadly interferes with the repose, and jeopardizes the primary union, of the part operated on. The mischief of its occurrence would be so great in some cases (as cataract extraction, etc.), that the anæsthetic advantages of the chloroform have altogether to be pretermitted. It is of great importance always that the sickness should be checked as soon as possible, and especially when it is a co-evil with shock; but, unfortunately, it is not by any means easy to cure. It must be remembered that the sickness is but one symptom of many which belong to the same cause; the depressed action of the heart, the pale skin, the extreme languor, and the sickness own one and the same cause: though that cause may possibly be the compound one alluded to in the remarks on shock. The treatment, therefore, should be of sufficiently general character to answer the double purpose of maintaining the circulation and composing the nervous system, especially the cardio-gastric. There is no medicine, nor is there any specific for the sickness of chloroform. If left alone, the stomach will recover by itself, though the sickness may last over many hours. The patient should be kept absolutely quiet and reposed; the attendant should be forbidden to plague him with frequent interruptions in order to give stimulants or drink. A teaspoonful of brandy may be given occasionally to maintain the circulation, and he may be allowed to suck small pieces of ice at intervals. Nourishments only tend to increase the sickness, and therefore should not be recommenced until the sickness has abated. From our experience of such remedies as morphia and opium, we cannot advise their employment; indeed, they frequently seem to do more harm than good.

Retention of urine is not an uncommon event after some operations, such as amputation of the thigh, and operations upon the rectum or other pelvic structures. It is a well-known fact, and we only mention it here, that the surgeon may be forewarned and forearmed. Inquiry whether the patient has passed his urine or not should be made invariably in the evening and on the morning following the operation; and if necessary the bladder should be emptied by means of the catheter. If the bladder is allowed to go unemptied, the first night after the operation is likely to be a restless one.

Pain and restlessness are the other symptoms after operations which may demand special treatment. Some surgeons make it a practice to give an opiate very quickly after an operation, in anticipation of pain, or with a view to induce sleep: but the indiscriminate use of opium in that way cannot but have an injurious effect upon the patient; when its effect has subsided, he is left enervated, restless, and all the more sensitive to pain, if there be any. The use of opium should be avoided, if it is not positively indicated; for its action, in blunting the patient's sensibility to unimportant impressions, cannot compensate for its interference with the various functions of the body at a time when their healthy action is so necessary to due nutrition and excretion. If, however, severe persistent pain (rare enough after

operations), or great restlessness, seems to demand the exhibition of anodynes, opium or morphia should be used; and one or the other should be given in full sufficient quantity, not in small but in doses large enough to insure the induction of good sound sleep. The subcutaneous injection of a solution of morphia is an excellent mode of administering it, especially when the stomach is nauseated or sick.

The only remaining subjects of importance in the management of patients after operations are those of traumatic fever and the disorders which may happen as complications. But since they have been fully described in other parts of this work, it seems unnecessary now to refer to them, farther than as the dangers and difficulties which, in his "watching" capacity, the surgeon should ever have in apprehensive dread, and against the occurrence of which he should constantly and intelligently remain on "guard."

COLLAPSE;

AND THE GENERAL EFFECTS OF SHOCK UPON THE SYSTEM.

By William Scovell Savory, Esq., F. R. S.

Revised by John B. Roberts, A.M., M.D.

Life may be destroyed by certain agents which leave no visible traces of their operation in any part of the body. Some forms of injury, as, for instance, a blow upon the epigastrium, may produce sudden death, and yet the most searching scrutiny shall fail to detect the slightest physical or chemical change in any organ or structure. Nay, further; life may be abruptly terminated by causes yet more subtle, such as sudden and powerful emotions of the mind.

This kind of death is very expressively termed Death from Shock. The heart is powerfully affected through the nervous system, and its action is arrested.

This conclusion is founded upon the following evidence:—

The absence of any discoverable lesion after death which can be connected with the violence which has proved fatal. Of course, it does not follow from the simple fact, that this kind of death is deficient in what would be called its morbid anatomy, that therefore no change incompatible with life has been produced; but if we add to this the fact that some of these extreme cases recover rapidly without any subsequent evidence of lesion, we may reasonably assume its absence.

[It is necessary to limit the word shock, and not include under it all cases of death occurring after injury without leaving definite post-mortem appearances. Undoubtedly many cases formerly, and perhaps at present, attributed to shock are really instances of rapid absorption of septic fluids; of anæmia produced by hemorrhage, which may have been interstitial; of fat-embolism after crushing of the marrow of bones; or of rapid abstraction of heat, due to sudden cooling of the abdominal viscera. It is evident that if death is produced by these causes it is unscientific to attribute it to shock. The so-called delayed shock, which is at times spoken of, seems almost an impossibility; and the symptoms so described are believed to be usually, if not indeed always, due to some cause similar to those just mentioned.

The close relationship of shock to the nervous system renders investigation of its pathology and etiology a difficult problem; hence we find many diverse views of its intimate nature. Death from shock seems to occur from sudden spasmodic contraction of the heart, or from sudden cessation of the contractility of the fibres of the cardiac walls. In the former case death must be immediate and the heart cavities more or less empty; in the latter it may be gradual and the cavities are comparatively full. It is stated by Jordan[1] that in death from shock, acting through the medium of the nervous system, electric irritability of the muscular system ceases with the arrest of circulation and respiration; or in other words, that chemical forces come into action at

[1] Brit. Med. Journal, 1867, vol. i. p. 260.

once, and decomposition or molecular death occurs simultaneously with somatic death.

At any rate, death from shock seems to occur through the heart, though the respiratory centres are doubtless involved in the general perturbation; the effect upon the heart probably depends upon some neurosis of the sympathetic system, but what is the true character of this nervous disturbance is not determined. Abscess of the brain and disease of the spinal cord do not give symptoms of shock, yet here the cerebro-spinal nervous centres at least are deeply involved in destructive processes. This may be because the nervous system at fault in shock is the sympathetic. Again, the brain of a pigeon may be cut away without the exhibition of shock, and we scarcely look upon concussion of the brain in man as an instance of pure shock. If we believe, however, that cerebral concussion is the result of minute lacerations of the brain substance, it approaches the condition of the peripheral cerebro-spinal nerves when subjected to injuries known to produce symptoms denominated shock. How far mental emotion alone can produce true shock it is difficult to say, as authorities are at variance upon this question. The lower animals exhibit shock from injury, and the insane human being doubtless does so; hence it is certainly more than a psychical production, and must depend upon some physical change in nervous tissue, though these factors may hold varying relations in each individual case.

It is averred by Jordan[1] that shock need not always be due to primary nerve injury, and he states that potassium cyanide injected into the blood acts directly on the cardiac muscular fibre, and by impairing its contractility gives rise to those numerous secondary effects of shock which depend on an arrested or imperfect supply of arterial blood.

In the investigation of shock it becomes probable that the disturbance of nervous equilibrium is to be found in the sympathetic vaso-motor function, of which so little knowledge has been firmly established. Dr. C. C. Seabrook attributes shock to paralysis of the vaso-motor centres,[2] and one of the most recent contributors to our knowledge of the subject, Mapother of Ireland, coincides in the view that the pathological changes producing shock are to be found in the sympathetic system. The condition in shock is,[3] in his opinion, spasmodic contraction of the minute arteries, due to vaso-motor influences; and this is proved, he thinks, by the weakened heart, contracted arterioles, lowered temperature, and ashy pale and shrunken skin. He further states that the essential phenomena of shock, such as spasm of arterioles, may be seen in a rabbit's ear when remote portions of the body are injured. The cerebro-spinal function, if this view be correct, may be almost disregarded in estimating surgical shock; and we should then expect crushing of a paralyzed leg to induce as great shock as a similar injury to a sound extremity. I do not know that any accurate observations have been made in the human subject in regard to this occurrence of shock after injuries to paralytic limbs, but I should hardly expect to see the same degree of shock exhibited as in crushing of non-paralyzed extremities.

Brown-Séquard's experiments,[1] made years ago, tend to show that the cardiac spasm in shock is due to a reflex influence transmitted by the sympathetic.

S. Weir Mitchell records[2] numerous cases in which wound of a nerve has caused instant loss of power in a remote region. This he attempts to explain by presuming that the shock had suddenly exhausted some ganglionic centre, and thus paralyzed its related muscle. He thinks that sudden death from shock may, on a somewhat similar theory, be explicable by absolute exhaustion of nerve force in some vital centre.

It is, however, hardly worth while to spend more time discussing the theories of shock, which may be reversed by future investigations in pathological science.

This is illustrated by the fact that many cases formerly called death from shock are now known to occur from fat-embolism. The importance of this subject, and its close relationship to shock, make it incumbent upon me to detail the nature and symptomatology of this obscure surgical condition. E. Wagner was, I believe, the first to suggest that sudden plugging of the pulmonary capillaries with fat globules might cause death; and in 1866 Busch published a case of death from fat-embolism. He also showed experimentally, that the crushed marrow produced by fractures might furnish fat, to be absorbed by the veins and to cause death from embolism. This subject has been studied with great care by numerous German investigators, and from the papers of Czerny, Scriba and others, the following facts have been obtained. The conditions especially liable to give rise to fat-embolism are

[1] Brit. Med. Journ. 1867, vol. i. p. 74.

[2] Trans. of Med. Soc. of State of Pennsylvania, 1881.

[3] Med.Press and Circular, Dec. 10, 1879, p. 496.

[1] British and Foreign Med.-Chir. Review, 1859, ii. p. 28.

[2] Injuries of the Nerves, p. 144.

compound fracture, though simple fractures, osteomyelitis, rupture of fatty liver,[1] and diabetes[2] are supposed to have been concerned in its causation. The fat is absorbed, often rapidly, by the veins and lymphatics, and produces embolic plugging of the capillaries of the lungs, kidneys, brain, and other organs. From Wiener's experiments[3] it would seem that disastrous results are only liable to occur when very extensive fat-embolism is present, and that ordinarily fatty embolism is harmless and not apt to give rise to symptoms of shock or collapse, because the fat is eliminated, perhaps by the kidneys. The symptoms are similar in many respects to those which we are accustomed to associate with the word shock, but they occur a day or so after the receipt of injury; hence, if there has occurred, after the injury, a distinct interval, in which the patient showed signs of reaction from shock, it may be considered that embolism of fat is the probable cause of the violent and fatal symptoms occurring later. Scriba,[4] whose investigations are very elaborate and but lately published, gives a very complete bibliography of fat-embolism, tables of urinary analyses in cases of osseous lesions, and a long series of cases of death from embolism, collected from various sources. He believes that emboli in the brain and cord, producing arterial anæmia and interruption of nutrition cause death.

The table of symptoms, which he has been led by experiments on animals and by observation to attribute to fat-embolism, is worthy of reproduction. I therefore translate it.

1. Fat in the urine, appearing periodically in a recognizable form; 2. Accompanying attacks of dyspnœa; 3. Lowered temperature; 4. Occasional occurrence of slight hæmoptysis, without fever and without dulness or râles; 5. Irregular action of the heart; 6. Collapse, with pallor of skin and mucous membrane; 7. Ordinary respiration, followed and interrupted by deep sighing respirations, and subsequently Cheyne-Stokes respiration; 8. Convulsions, and paralysis, often bilateral in character; 9. Diminution of reflex excitability.

The diagnosis of fat-embolism from shock is to be made by the later period at which the former occurs, by the interval of apparent improvement between the time of injury and the onset of serious symptoms, by the absence of visceral lesions, and by the symptoms mentioned above, which do not in all respects correspond with those of ordinary shock.

Venous thrombosis, due to lesions of veins at the time of injury, may produce somewhat similar symptoms, but not at as early a period as fat-embolism.

Unfortunately nothing practicable in the way of treatment has as yet been advanced for the relief of fat-embolism. It is readily appreciated that this difficulty is due to the fact that symptoms of embolic plugging with fat-globules are only presented after the process has occurred, for it is probable that embolism takes place a few hours after the injury, though symptoms may not be exhibited until a considerable number of hours later. In the present state of surgical knowledge the interest of fat-embolism, to the practical surgeon, centres in its resemblance to surgical shock, which it simulates, but from which it should be differentiated. It is possible, however, that the treatment of shock by hypodermic injections of ether, which has gained some reputation of late years, may owe its efficiency and reputation to a solvent action of the ether upon fat emboli, which present symptoms so similar to shock that observers may have been misled in their diagnosis. This is a suggestion, rather than the statement of a belief that such is the case.]

Although—granting the result of such experiments to be not always uniform—there is ample evidence to show that the heart in its action is not directly dependent on the general nervous system, that is to say, it will continue to act after the removal of the whole of the great nerve-centres, provided the operation be gently and gradually performed; yet it is equally clear and certain that the heart in its action is most powerfully influenced through the nervous system. This, indeed, is familiar knowledge to every one whose heart has ever "leapt from joy" or "sunk from fear." And this influence, if sufficiently intense, may stop its action altogether. This is what occurs in death from shock.

Death from shock, then, is the result of a sudden and violent impression on some portion of the nervous system acting at once through a nerve-centre upon the heart and destroying its action.

This conclusion is confirmed by the condition of the heart after death.

After death the heart is found full of blood. All its cavities are distended; although this is most obvious in the auricles and the right ventricle, the left ventricle not so readily yielding. The great veins, and the venous system generally, are also gorged.

The blood, as a general rule, coagulates very imperfectly. A considerable portion of it remains fluid, and the clots are loose and dark. In none of my experiments or observations have I found it

[1] British Med. Journal, Oct., 1877.
[2] Edin. Med. Journal, July, 1879.
[3] Arch. für. Experim. Path., Bd. xi.
[4] Deutsche Zeitsch. f. Chir., 1880.

altogether fluid, although there is no reason to doubt the statement of Hunter and others, that this is sometimes the case. Rigor mortis also commonly, perhaps always, occurs; and it is, sometimes at least, very strongly marked. When slight and transient it may easily escape notice.

Although the effect of shock is most obvious and immediately important upon the heart, yet there can be no question that its influence is general throughout the system, operating more or less upon all the organs. This relation which is established between any organ or structure and other parts through the nerve-centres has been aptly termed sympathy.

Nothing short of demonstrative evidence—actual experiment—could have established the fact that the whole of the great nerve-centres may be gradually removed without directly destroying the action of the heart, and yet that its movements may be at once arrested by a sudden and severe impression acting through them. This significant fact is especially important in relation to the present inquiry.

But these or other causes may produce an effect, short, indeed, of immediate death, but which nevertheless leaves a person on the verge of dissolution; and this condition is called Collapse. Its features in the extreme form are plainly marked.

The patient lies in a state of utter prostration. There is a striking pallor of the whole surface; most marked, from its contrast to the natural color, in the face. The lips even are quite pale and bloodless. There is a cold clammy moisture upon the skin, and often distinct drops of sweat upon the brow and forehead. The countenance has a dull aspect, and appears shrunken and contracted. There is a remarkable languor in the whole expression, and especially in the eye, which has lost its natural lustre and is partially concealed by the drooping of the upper lid. The nostrils are usually dilated. The temperature is considerably reduced; and, if the person be able, he will complain of feeling cold, and perhaps shudder. Muscular debility is extreme—apparent at a glance in the condition of the lips and hands—occasionally even to the relaxation of the sphincters. The pulse is generally frequent, sometimes irregular, always very feeble, perhaps quite imperceptible. In this latter case, although the ear may detect the fluttering action of the heart, the pulse does not reach the wrist. The respiratory movements are short and feeble or panting and gasping, "wanting the relief of sighs," sometimes imperceptible, although in the majority of such cases some action of the diaphragm may be detected by careful observation. Vertigo with dimness of vision supervenes. As the rule, there is not complete insensibility, although there is much variation in this respect, depending no doubt upon the nature of the injury; but the person is drowsy and bewildered, yet conscious and perhaps rational when roused. Sometimes the intellect is singularly clear, and the senses perfect; the hearing occasionally even painfully acute. In the less extreme cases there are often nausea and vomiting with hiccough. The last is very variable in its occurrence.

The signs of syncope are those of collapse. Travers says, "a fit of syncope, and the recovery from it, present an epitome of the phenomena of shock."[1] So far as they extend, the symptoms of an ordinary fainting-fit are analogous to those of collapse. "They differ in degree and duration more than in kind." It is true that in syncope there is more uniformly a suspension of the mental faculties as well as of the senses and voluntary powers, but this may perhaps be explained by the fact that causes which produce syncope act more uniformly upon the brain. It has already been remarked that in collapse there is considerable variation in this respect—a variation doubtless due to the nervous centre through which the shock operates. In syncope the crisis is more rapid. In collapse the effects are more extensive and profound.

[The symptoms of shock vary with the individual as well as with the extent and locality of injury; hence it is often impossible for even an experienced observer to determine at once whether organic lesions of severity accompany a given case of severe shock. Authors have attempted to study the varieties of shock, by making a classification somewhat as follows: 1, transitory; 2, protracted; 3, secondary or delayed; 4, insidious. The first two and the last varieties seem scientific and legitimate, but I am not convinced of the possibility of secondary or delayed shock. McLeod and others have affirmed the existence of such a condition, and Hamilton,[2] while stating that he has never met with examples, says that he does not deny its possible occurrence. The concatenation of symptoms, often called delayed shock, is in my opinion due to a very different pathology. The very essence of shock is its immediate production before inflammation, septicæmia, suppuration, or fat-embolism can occur. If the symptoms are delayed, I believe them due to some secondary change, such as those mentioned, and the well known rapid onset of some

[1] On Irritation, 1827, pp. 127, 128.
[2] Military Surgery.

of these pathological processes readily comports with the time at which the so-called delayed shock supervenes. Another explanation that I venture to offer for some of these cases is the reactionary mental exhaustion that may occur after great excitement, and simulate shock.

The symptoms observed during shock are fully detailed by our author, and to his description I shall merely add some supplementary words.

The symptoms are more pronounced as injuries of the extremities approach the trunk, and are more so in wounds of the abdomen than of the chest. Shock certainly does not depend for its existence upon the occurrence of pain, for it rather renders the patient insensible to pain, and may be presented, indeed, when an operation of expediency has been performed under anæsthesia. The observations of Mitchell upon shock and pain in gunshot lesions of the large nerve trunks deserve mention in this connection. He studied injuries of the brachial plexus and its large branches, where there was no early or severe hemorrhage, and discarded wounds of the lower limbs because the patient would almost always fall from locomotion being interrupted, without reference to shock. Out of 56 patients only 2 had acute pain; and 29 were able to walk away at once or in a few minutes, while the remaining 27 either fell insensible or dropped at the time of wounding without loss of consciousness.[1] It would seem then that about one-half the cases injured by gunshot wounds of nerve-trunks showed decided shock. It must be remembered, however, that bleeding and emotion on perceiving the paralysis would soon increase the depression of such patients and aggravate the symptoms presented. Panic suddenly produced closely resembles shock, but it and prostration from hemorrhage should, whenever possible, be differentiated from shock of injury.

The circulation during shock is enfeebled, and, according to Jordan, the cardiac pulsations are lessened in frequency, for he believes that the acceleration of pulse, so often observed, is really a sign of beginning reaction,[2] and that the heart is slowed during the existence of pure shock. In the same way he maintains that vomiting does not occur in profound shock, but is a symptom of the reaction stage. The enfeebled heart and the contracted condition of the capillaries, already described, cause the pallor of the surface and the capillary stagnation in collapsed patients. An interesting study of sphygmographic tracings, obtained during shock, is presented in Mr. Jordan's paper.

[1] Injuries of Nerves, pp. 140, 141.

[2] British Med. Journal, 1867, vol. i., pp. 136, 258.

The temperature of the surface in shock has long been described as lowered, but no one, as far as I know, has made such elaborate investigation of the temperature records of surgical shock as Mr. Wagstaffe.[3] In a series of fracture cases, most of them compound in character and requiring amputation, he found the axillary temperature to be lowered in every instance but one. The average depression of temperature was 1.7°, though when he excluded one case in which hemorrhage might have been a factor in the fall of temperature, the mean fall was 1.2°. In his investigations of shock after capital operations, such as herniotomy, ovariotomy, and amputations, he found a mean fall of 0.3° in the cases that subsequently recovered, and an average depression of 3.7° in those which proved fatal. The deduction that seemed legitimate was that a fall of more than 1°, produced by shock of operation, justified an unfavorable prognosis as to the ultimate result of the case. In fractures of the spinal column he found, in the few cases observed, that the temperature-fall apparently coincided in some degree with the location of the fracture. The nearer to the medulla oblongata the seat of lesion, the greater was the decrease of temperature. In one remarkable case of fracture in the cervical region, in which the observation was made three hours before death, the axillary temperature registered only 81.75° or 16.65° below normal. In this case, however, post-mortem examination showed the sixth cervical vertebra broken, the cord compressed, and extravasation near the sympathetic nerve. These injuries were doubtless important factors in producing the fall, which cannot be wholly attributed to shock.

An epitome of Mr. Wagstaffe's results, though derived from comparatively few cases, will be interesting. He found as follows:—

	Not Fatal. A mean fall of—	Fatal. A mean fall of—
In burns and scalds,	0.1°	3.5°
In severe fractures,	1.6°	2.1°
In operations without undue hemorrhage,	0.3°	nearly 3.0°

Some cases recovered which showed much lower temperature than would seem compatible with a favorable prognosis. One man, who was admitted for suicidal cut-throat, and who had bled profusely, recovered, though his temperature on admission was 91.2°. This case was not included in the above table, because the fall was probably due to some extent to the hemorrhage and mental perturbation. It illustrates the diminution of bodily heat that may occur at times without being symptomatic of fatality.]

[1] St. Thomas's Hosp. Reports, 1870, p. 465.

It can scarcely be necessary to remark that the symptoms just enumerated vary much in degree even in cases of complete collapse; and from this we form our opinion of the immediate result. As a general rule, the less the manifestations of life, the worse the prognosis. When the respiratory movements have ceased and the pulse is imperceptible, we anxiously listen in the region of the heart, and if we hear nothing there, life may be extinct. But it does not follow that recovery is impossible even in this desperate condition. In the first place, there may be some action of the heart still continuing, although too slight to be audible outside, and with this amount of life there must be some hope. But setting this question aside for a moment, others arise. In the absence of any discoverable lesion which in itself must prove mortal, what is there in such a case to preclude the possibility of recovery? By what facts are we convinced that in such a case a person is really dead? On the contrary, there is good reason for doubting; and if a doubt exist, the duty of the surgeon is clear.

In experiments upon the higher animals, when the action of the heart is arrested by a shock, as by sudden destruction of the nerve-centres, its movements will, in many cases, be subsequently resumed; and, if artificial respiration be kept up, they will continue for a considerable time. Further, when temporarily paralyzed by a simple shock, uncomplicated with any lesion, as, for example, by a blow upon the epigastrium, or by a current of electricity, the heart will often, after a shorter or longer interval of repose, resume its action and permanently recover. There can be no doubt that instances of this kind have occurred in the human subject. It is needless in this place to enter into a consideration of the ingenious explanation which has been offered of this fact—that it is due to a temporary exhaustion of power, which, after an interval of rest, is renewed. It is enough to have the fact established. Nay, far less than this would be sufficient to demand from us the adoption of any means, for any length of time, which might possibly succeed in restoring animation.

When a person recovers directly from a state of collapse, he passes through the stages of what is termed reaction.

This process, in the most favorable cases, is gradual, often occupying many hours. It may be many days before the system has thoroughly rallied and the several functions have resumed their wonted harmony. Amongst the earliest symptoms of healthy reaction are improvement in the power and rhythm of the pulse, and fuller inspirations; an occasional deep sigh is, I think, a very favorable sign; so also is the power of swallowing; and confirmatory of these, an increase of the temperature. Vomiting is commonly one of the early symptoms. An important sign of still further improvement is an inclination to shift the position; to move from the supine posture—which is emphatically the posture of debility—to one side. Subsequently there is, for a time, some excess of action, but it may be gradual and very slight. The person is a little feverish. The skin becomes rather hot, the face flushed, the pulse is rather frequent, and perhaps bounding, the urine scanty and highly colored, there is thirst, headache, and some restlessness. But at length the skin becomes moist, the person falls asleep, and awakes convalescent.

[*Reaction* is the stage of shock that forms the route to a normal condition of the vital functions, and although we do not desire it to be inordinate, giving rise to traumatic delirium and other untoward symptoms, it is usually preferable to have an excess than a deficiency of reaction. The latter indicates nervous depression and lethargy, while the former generally shows at least activity of the vital forces; and it is always easier to control force than to create it. A distinction should be made, however, between activity or power and the condition of prostration with excitement spoken of by our author.

The time at which reaction will begin, or if begun, when it will become complete, cannot be foretold, since severe shock may be of short duration, and slight shock may continue its unfortunate effects for hours or days.]

It has been often observed that recovery after severe shock is not always uniformly progressive. The symptoms sometimes fluctuate very obviously. A short period of improvement in the pulse, respiration, and temperature, is succeeded by an interval of failure; and this alternation may recur again and again, each relapse, however, being less marked, until reaction is thoroughly established.

Other things being equal, the longer the symptoms of reaction are delayed the more unfavorable is the prognosis. If at the expiration of some hours no symptom of its commencement appear, the patient's condition is certainly desperate.

But a state of collapse may end neither in immediate death nor in direct recovery. The reaction may be imperfect, and that condition which Travers has described as "prostration with excitement" may supervene, and this may lead indirectly to a fatal or favorable issue.

This state is marked at first by dry heat of the skin, a flushed face and anxious expression, a rapid and bounding pulse, which is sometimes even sharp, but always

easily compressed. The respiration is hurried and imperfect, with partial and irregular sighs. The tongue is tremulous; there is often urgent thirst; vomiting is a frequent and sometimes most obstinate symptom; there are occasionally rigors. The languor or stupor of collapse is succeeded by restlessness, jactitation, tremor and twitchings of the muscles, præcordial anxiety; often, but not always, delirium of various degrees, from occasional incoherence to wild and fierce excitement: this most frequently occurs, and is more marked, during the night. There is either an entire absence of sleep, or it is partial and interrupted, and is succeeded by no relief. As the exhaustion increases, the skin becomes covered with a cold and clammy sweat, which is very often profuse. The face becomes pale and the expression haggard; the pulse innumerably rapid, irregular, fluttering; subsultus comes on; slight convulsions; coma more or less profound; and death.

The symptoms are subject to considerable variation, both with respect to the periods at which they supervene and their manifestation. Perhaps the disturbance of the cerebral functions is, of all, most variable. There may be little more than a peculiar irritability of manner, with an increased disposition to talk, sometimes rationally, occasionally incoherently. Often there are strange illusions, attended with a peculiar dread of impending evil; or, on the other hand, there may be the fiercest maniacal raving. Lastly, it may present all the features of—in fact, be—a case of ordinary delirium tremens.

Now these symptoms of extreme excitement, leading so rapidly to fatal exhaustion, are unquestionably evidence of excessive action and deficient power. Hunter calls it irritability. There is no more important subject for inquiry than the relation of action to power in the living body. In the condition of health the balance is uniformly maintained, or at least the supply is equal to the demand. But, if from any cause the power of an organ, on the function of which life is immediately dependent, be much impaired, this difficulty arises: its function must still be discharged to an extent at least sufficient for the purposes of life, and therefore deficiency of power may need to be redeemed by increase of action. But action involves exhaustion, and repose is needed for repair. The greater the effort, therefore, the greater the exhaustion. But again, decreasing power must be met by increasing action. Thus cause and effect react each on the other; the relation between power and action becomes more and more reversed, until at length, the supply diminishing, and the demand for action and repose alike augmenting, the crisis, with rapidly increasing pace, is hurried on.

No organ illustrates this so strikingly as the heart, and under no circumstances better than in the present case. An impression is produced upon the heart whereby its power is for some time impaired. But, that life may last, it must still to a certain extent circulate the blood. If it be too feeble to accomplish this necessary task at its ordinary rate of action, its frequency must be increased. But action is succeeded by corresponding exhaustion; and so, if the supply prove unequal to the demand, follows prostration with excitement—deficient power and excessive action; the pulse increasing in frequency as it fails in force.

In this way collapse may indirectly terminate in death, through excessive and exhausting reaction; or, if happily the power be sufficient to restore the equilibrium, in ultimate recovery.

In reference to these cases it is interesting to note, that in others reaction may be for a long while—perhaps some days—very partial and defective; sufficient, indeed, to protract life, but rendering the prognosis extremely doubtful.

But the effects of a shock to the system are not always thus limited in their nature and duration. Those which have been described may be termed primary or direct, but sometimes these are succeeded by others more remote and secondary, including perhaps, after a shorter or longer interval, grave mischief, or it may be even death. It is not uncommon to have various forms of local disease or disturbance of the general health referred to some previous shock which the system has sustained. "He has never been the man he was since," is a familiar allusion to a case of this kind; and, after making every allowance for exaggeration and misinterpretation, the relation of cause and effect between some previous shock and present mischief may be often clearly and unequivocally established. [Dr. Peter Hood[1] believes that cardiac weakness may be developed as a remote consequence of such injuries as railroad shock; and advocates phlebotomy at the time of injury as a prophylactic measure.] Nor does it seem difficult to conceive how some defect or perversion of nutrition may gradually supervene upon the sudden and severe commotion of a violent shock. Into a description or even an enumeration of these various effects it is not practicable to enter here, but it may be remarked that of late years the subject has attracted much attention in connection with accidents on railways. For the cases thus furnished not only excite professional interest from the striking

[1] Lancet, Feb. 27, 1875.

symptoms they exhibit, but public interest also from the pecuniary question usually involved.[1]

It must be added, however, in relation to this very interesting subject that, as many cases show, there is no constant proportion in their severity between the immediate and remote effects of shock. Some of the worst cases of this kind, those which after long periods of suffering have at length proved fatal, have at first exhibited, if any, apparently only the most trivial symptoms. There is abundant evidence to show the need of anxious watching in all these cases.

The principal causes of collapse are :—

Injuries sudden and severe, or extensive, as contused and lacerated wounds, involving a considerable amount of texture—the crushing of a limb, for instance. Burns present familiar and striking examples of extreme collapse produced by this cause. Under this head, too, come capital operations.

Injuries of very important organs, as the liver, or other of the viscera; or of the joints; or of other organs abundantly supplied with nerves. Sudden crushing of the testicle has proved fatal.

Pain alone, when intense and protracted, has proved fatal in this way; and it appears, in a case related by Sir A. Cooper in his first lecture, that sudden relief from great agony was attended with the same untoward result.

Certain poisons operate in this manner, depressing the system so suddenly and severely as to produce a state of collapse;—tobacco, for example. And drastic purgatives have in some cases induced a similar condition.

The purest examples of collapse are those which are produced simply by what is termed a shock to the nervous system. A severe blow upon the epigastrium, for instance, may produce immediate death without any detectable lesion. A current of electricity acts in the same way, as in death from lightning. Simple concussion of the brain is, perhaps, the example most commonly presented to our notice as surgeons. In this case, however, the ordinary effects of shock are complicated by the insensibility which naturally results from the nature of the injury. [In concussion of the brain there is probably concomitant laceration of brain substance in nearly every instance.]

Accidents on railways present striking examples of an analogous kind. After a collision, different persons are found in various degrees of collapse without perhaps any visible injury or local lesion. The condition is referred to concussion, not of the nerve-centres only, but of the whole system—to shock of both "body and mind."

There can be no doubt that in some cases a mental emotion alone may destroy life. And although this extreme effect is very rare, yet doubtless there is no source of shock to the system so frequent as the mind. Its subtle operation is most marked in its relation to what are termed the organic functions. Its influence upon the functions of the stomach and intestines, liver, kidney, skin, and other organs, is well known. A familiar instance of the extent of its influence is seen in women during lactation. The qualities of the milk are from this cause often suddenly changed, so as to produce very serious effects upon the infant. In some recorded cases the result has proved fatal.

It is remarkable and characteristic that severe shocks to the system from mental emotion, after the more immediate effects have passed away, often leave some organ permanently impaired in its function. Sudden fright, for instance, has produced deafness.

Some injuries tend to produce collapse in more than one way. The collapse following gunshot wounds, for example, may be due partly to the extent of the mischief and the organ or organs involved in it, assisted more or less by hemorrhage according to its degree; and undoubtedly, in many instances, partly to the effect upon the mind of a sudden, and probably severe, injury, the nature and extent of which are doubtful.

Again, the shock produced by the cold douche is doubtless increased by the depressing effects of great and rapid reduction of temperature.

The effects of shock are aggravated by loss of blood. Hence a comparatively slight injury, if accompanied by considerable hemorrhage, will produce a more profound impression on the system than one much more severe without this most important complication.

But hemorrhage alone, if sudden and profuse, will produce collapse. Excessive hemorrhage, even if gradual, will produce a state of extreme exhaustion and debility, and death from anæmia; but this is not the same as collapse from loss of blood, which depends rather upon the suddenness than upon the amount of hemorrhage. In sudden and profuse hemorrhage, the heart and system generally are not only directly affected, but indirectly through the great nerve-centres by the abrupt abstraction of blood.[1] And although after death from simple shock without any loss

[1] For the best and fullest information on this subject, the reader is referred to Erichsen on Railway Injuries, 1866.

[1] See Marshall Hall, Med.-Chir. Trans., vol. xvii.

of blood the heart is found distended with blood, while after death from sudden hemorrhage it is more or less contracted, yet the difference appears to be due principally to the quantity of blood in the system; for if in the former case the distended heart be relieved by opening a large vein, it will assume very much the condition met with in the latter case. Moreover, the symptoms produced in each case are to my observation similar; and although it is of the greatest importance to distinguish between the causes, yet in either case the condition induced is a state of collapse.

Perhaps the chief distinction between the symptoms of collapse the result of sudden and profuse hemorrhage, and of that from other causes, consists in this: in the former the effects are for a time most obvious on the vascular system; the functions generally not appearing depressed to the same extreme degree. Thus, when the pulse at the wrist may be imperceptible and the heart's action hardly, if at all, audible, the voice will continue clear, firm, and loud, and the physical and mental powers considerable. Such a condition is often witnessed in hemorrhage during labor. This contrast is, however, of course, only temporary; and the same is sometimes seen in collapse from other causes, as, for instance, in Hunter's own case.[1]

[A state of collapse is frequently exhibited in the course of certain blood diseases, such as cholera, yellow and typhoid fever. Especially is it seen in perforation of the intestine as a result of typhoid fever.]

Hitherto the influence of shock has been considered only in its extreme effects when directly producing a state of collapse; but it must be a very narrow view of the subject which would overlook its less severe though much more frequent results. It may operate in any degree, and produce in one case, as has been already seen, instant death, or a state not to be distinguished from it for a time even by the most anxious scrutiny; in another case effects so trivial that the symptoms pass unnoticed or unheeded by a superficial or careless observer.

There are many instances on record, and many more known to every surgeon, of death from this cause less sudden, but in many instances scarcely less inevitable. In some cases injuries or operations, comparatively trivial in their nature, induce a condition of otherwise unaccountable debility, and terminate in death by asthenia. A careful inquiry into the history of such cases will often elicit facts which enable us to reconcile the apparent disproportion of cause and effect.

[1] Works, by Palmer, vol. i., p. 244.

After injuries or operations sufficiently severe to produce a serious impression upon the system, yet by no means amounting to a condition of collapse, reaction is sometimes defective or unduly delayed. The patient remains depressed; there is no heat of surface; the pulse is weak and perhaps unsteady; he does not sleep soundly, although he may be constantly dozing; and the stomach is often irritable. In a word, there is an absence of "sympathetic fever."

There are some circumstances which greatly affect the result of shock in its various degrees upon the system.

General debility favors the influence of shock. A weak system is more easily impressed and disturbed, and reaction fails from want of power.

In the same way very much depends upon what is termed the state of the constitution, or rather the idiosyncrasy, of the individual. An injury which will produce no visible effect upon one man, scarcely inducing even a temporary disturbance of any function, will in another produce a most serious and enduring impression. Yet both of these subjects shall be previously in perfect health; but there is often, though not always, a visible difference in their temperament, by which our judgment is materially guided in calculating the probable effect of any operation or injury.

The effect of any shock is most disastrous in those whose constitutions have been previously broken down by debauchery or excess. These labor on, inadequate to the ordinary demands of every-day life, and utterly unequal to the extra claim which a comparatively small injury makes upon the vital powers. These are the cases that so often terminate in delirium tremens.

[Disease of the kidneys and heart may exert a disastrous influence upon the degree of shock after injury or operation. Hence, the urine and heart should invariably be examined before major operations are undertaken.]

As life declines, the vital powers diminish, and this decrease becomes strikingly apparent when any injury or disease leads to an increased demand upon the resources of the system. There is less power in reserve, if it may be so expressed; less constitutional capital. In old age the system may be equal to the task of maintenance, but it is much less capable of the extra exertion of repair. Hence those advanced in life are slow to rally from the effects of shock. Reaction fails. Sudden confinement to bed alone often produces a very serious impression upon old people. The system in advanced life often appears unequal even to this change. Thus an injury in itself insignificant may in this

way, by rendering confinement to bed necessary, lead to a fatal result. Surgeons are aware of this, and in the treatment of fracture of the neck of the femur, for example, are anxious to see the patient about again as soon as possible.

The capacity for reaction must not be confounded with the power of resistance. Indeed, generally they are inversely proportioned to each other. A certain degree of shock may produce a very obvious disturbance of the system in the young, which nevertheless soon subsides. In the old the same influence may be attended with scarcely any visible effect, yet when an impression is made it endures. So the influence of shock is more manifest but more transitory in the young; less obvious but more fatal in the old.

Apart from all considerations relating directly to the body, the character and condition of the mind exert a more subtle but most important and interesting influence upon the effects of shock, especially in its less extreme degrees. Perhaps it is not always known how much the result of an operation is regulated by this cause. It seems that in some instances a firm and deeply-rooted conviction that recovery is impossible may alone suffice to prevent it. There are instances on record of death after the most trivial operations, which can be explained in no other way. Nay, more, as already noticed, death has been directly produced from mental emotion, without the intervention of any other cause. And even in such instances as those related by Travers and others, it cannot be regarded as a predisposing cause only. The trivial operation is but indirectly connected with the fatal result as the exciting cause of the mental condition. Although these extreme instances are comparatively rare, yet, on the other hand, it may be affirmed that in every case the result of a severe accident or operation is more or less influenced by the state of the mind. We speak familiarly and truly of certain emotions as depressing, and of others as exciting; and it is not difficult to understand that much must depend upon the question—With which of these is the inevitable shock of an operation or accident to be associated?

Those who have watched patients the most closely attach the greatest weight to this matter. A nurse has often considerable advantage over the surgeon in this respect. She becomes more thoroughly acquainted with the condition of the patient's mind, and its influence upon the system. I have more than once talked over this subject with the intelligent sisters of the wards which are more especially devoted to cases of operation at St. Bartholomew's Hospital; and I think many would be surprised at the vast importance they attach to the condition of the mind in determining the result. Many times, when to a passing observer the state of a patient has appeared to be in every respect satisfactory, I have seen the sister shake her head, and heard her say, "He would do very well if he were not so nervous; but he will never get better while he continues to persuade himself that he cannot;" and rarely has the prediction proved to be false.

There are at least two distinct forms of mental influence operating powerfully upon the result. The first is either the buoyancy produced by hope and a firm belief in a successful issue, or the depression produced by despondency and a rooted conviction that the result will be fatal. The second is either a calm and equable disposition, patient and enduring, or a peevish and irritable temper, restless and complaining. The former of these are usually influenced by age, and the latter by sex. The young are the most hopeful, and women as a rule endure most patiently.

In this way may be explained, without impugning the authenticity of the actual facts, many of the marvellous stories which some people like to relate; such as the prognostication of the result of an operation or injury which at the time seemed opposed to all reasonable calculations; the verification of dreams, etc.

Other conditions being the same, the immediate effect of any shock upon the system varies as the intensity of the impression. Hence the greater fatality of large amputations for accident when compared with those for long-standing disease. In the former case a sudden and severe injury is closely followed by a large operation, and the person passes at once from a state of activity to one of close confinement. Here are all the conditions calculated to produce a profound impression. In the latter case the person has become accustomed to confinement. His habits of life after the operation are not abruptly changed. There is no shock from an injury antecedent to the operation, and the system is less startled by the irritation of the wound when previously to some extent prepared for it by the accustomed irritation of the disease.

A similar explanation may be applied to the comparatively great danger of what are termed "operations of expediency." The shock to the system is greater when previously unaccustomed to any unusual demand upon its resources.

[Surgical shock is greatly influenced in degree by individual susceptibility, by location of injury, by sex, age, and previous disease, as well as by a number of other concomitant circumstances. Many of these matters have been freely discussed

in the text, and of them I shall say but little; a few influencing circumstances, however, that have not been detailed by our author, I shall speak of more at length.

In regard to locality of injury Longmore's statistics[1] are valuable, and show that death from shock is rare after wounds of the extremities, unless they are very severe. Of 100 consecutive deaths in the Crimean war, 22 are recorded as from shock, but of these in only 1 case was the injury confined to a *primary* wound of an extremity. Out of the 22 cases of death, however, 16 were penetrating wounds of abdomen, pelvis, or chest. Of these 16, there were 13 of the abdomen. This shows that abdominal wounds are accompanied by great shock. Wounds of the brain and cord give rise to great depression similar to shock, but here we have direct injury to the nervous centres, which renders the diagnosis between simple shock and cerebritis or myelitis a difficult problem. Whether the degree of shock following injury to a previously paralyzed limb is equal to that resulting from wounds of a healthy extremity I am unable to decide, as I have no accurate observation of the subject.

Burns and extensive skin injuries are associated with great shock, which may be due to the extensive nerve distribution involved, or to some subtile deleterious influence from arrest of the blood-purifying functions of the capillary and lymphatic circulations in the skin and subcutaneous tissues.

The relation of temperature to the condition under consideration is interesting. Animals are said by Mapother[2] to be more easily killed by shock the higher their bodily temperature. Another experiment, germane to our subject, is the production of death from cardiac spasm, when a shaved rabbit is suddenly subjected to severe cold by being placed in ice-water. The statements show that there is some relationship between shock and external temperature. One of the worst cases of shock, to be followed by recovery, that I ever saw, was caused by a pistol-shot wound of the abdomen. The man, after the injury, had waited some time, on a cold winter's night, for a street-car, and then ridden a considerable distance. The shock, when I saw him, was profound, due to the locality of the injury, the exposure to cold, and the fatigue of travelling. His critical condition was combated by hypodermics of whiskey and ammonia, and the other methods of treatment to be described, and he fully recovered.

Previous starvation has a depressing effect on the patient, and increases the shock. Experiment has shown that animals will fall down dead from the slightest shock, such as cutting a pigeon's claws, if subjected to a process of starvation previously.[1] This may be a factor in the shock seen after injury, in cases of accident among the lower classes, that has not been sufficiently recognized. It points to the necessity of combining nutriment with other remedial measures in the treatment of the condition.

A statement, which will perhaps surprise many, is made by Dr. Peter Hood in the Lancet, February 27, 1875, p. 300. He says that in railroad and gunshot injuries it has been observed that persons, who have lost blood copiously, do not suffer from the nervous depression so common among those who have sustained injuries unattended with hemorrhage. This is given as one reason for advocating phlebotomy in the treatment of certain cases of shock, which operation, he says, tends to relieve the heart and vessels oppressed by the thickened blood, and enabling by the former to regain power, tends to establish a more vigorous flow of blood through the brain.]

In the treatment of collapse in its extreme degree, our object is to maintain, and, if necessary, to excite, a sufficient amount of action for the purposes of life till the system is enabled to rally from the exhaustion produced by the shock. A certain amount of action is essential to life. The heart must beat and the patient must breathe. Here it becomes necessary to distinguish the two cases previously described—collapse without hemorrhage, and collapse the result of sudden and excessive hemorrhage. With regard to the treatment and the issue of the case, this distinction is of primary importance.

First, then, of collapse the result of a severe shock without hemorrhage. Supposing the most desperate case, in which no sign of life can be detected: is anything to be done? So long as the slightest doubt remains, the case is not absolutely hopeless. In the absence of any positive evidence to the contrary, such as the lapse of time or the complication of irreparable injury, we assume that recovery is not impossible. When the respiratory movements have ceased, artificial respiration should be patiently practised; and if there be any evidence of the heart's action, it should be perseveringly continued until we obtain evidence that the function is naturally performed.

If no evidence of the heart's action be detected, can anything be done to excite it?

If an animal be killed by shock, such as

[1] Gunshot Injuries, pp. 149–50.

[2] Med. Press and Circular, Dec. 10, 1879.

[1] Med. Times and Gazette, 1860, ii., p. 151.

sudden destruction of the spinal cord and brain, and the chest be opened within a minute or two of the operation, the heart will be found motionless, or with the slightest flickering movement, most apparent in the auricles, and *distended* with blood. The veins too are in the same engorged condition. If now the right auricle or ventricle be punctured, blood will pour out, and this will be instantly followed by a striking increase in the heart's action, which will continue to improve for some time. Or if the distended jugular vein be opened in the neck, the heart will resume its action as soon as relieved. While the heart remains paralyzed by distension, it cannot recover.

In such a case, therefore, the superficial veins of the neck should be examined; and if distended, the external jugular should be opened. This treatment is sanctioned by both reason and experiment. Nothing else seems to offer any prospect of success. Electricity has been recommended; but even if it could be obtained at the precious moment when required, the principle of its application is, to say the least, a very doubtful one.

While these means are practised, the temperature of the body must be carefully maintained. This important precaution is apt to be neglected during the prosecution of more active measures. As the circulation fails, the temperature falls; but the person must not be allowed to grow cold.

If there has been considerable hemorrhage, our chances of success are greatly diminished; and when such extreme collapse as that just spoken of is the result of hemorrhage, the case is desperate indeed. In such a case, transfusion is the sole means that offers a chance of life. The difficulty of its immediate adoption is generally fatal to its employment; but if practicable, it should certainly be attempted. It is unquestionably "a fair and rational expedient."

But if we should happily succeed in exciting the heart to resume its action, or in less desperate cases where it still acts, when the symptoms are such as were described at the commencement, how shall these actions be best maintained?

While, on the one hand, it is absolutely essential that these actions shall be to a certain extent continued at whatever cost, on the other hand it is of extreme importance that the flagging powers be not unnecessarily tasked. Time is a more important element in these cases; and if in the interval we can keep the patient alive, the system will sooner or later rally from the effects of shock, if uncomplicated with any mortal lesion. The chief point of difficulty is to decide how much to do; when to act, and when to desist. If by imprudent and impatient attempts to increase action, we draw too largely on the already exhausted powers, we hasten the catastrophe; but nevertheless we watch narrowly that the feeble functions do not decline. "We have two points especially to bear in mind," says Travers, "first, maintaining action; secondly, not forcing it." During this critical period such a case should not be left for an instant. The patient must be strictly kept in the horizontal position, with the head on a level with the trunk; and he should not be raised to any extent till reaction is fairly established. Amongst drugs there are many stimulants, but in these cases nothing is equal to brandy. Its effects are more certain and decided, and it suits the stomach best. It will remain when all other stimulants are rejected. The state of the circulation and the temperature are the guides to its use. However, there should be a limit even to the administration of brandy. If no effects are apparent after an ounce or two have been swallowed, it is very questionable if any advantage will be gained from a larger quantity. It frequently happens, that after several ounces of brandy have been given without benefit, they are suddenly returned. The stomach, no longer able to absorb its contents, is thus stimulated to expel them. The application of heat to the epigastrium and the extremities is most useful. Flannel cloths wrung out of hot water and applied to the pit of the stomach are often of signal service. If the patient be unable to swallow, stimulating enemata should be administered. With all this, the temperature of the body generally should be maintained. As the natural production of heat fails, its loss must be prevented as much as possible and supplied by artificial means. Nourishment should follow stimulants very closely. Stimulants alone may be required in the first emergency, but they soon prove useless if unaccompanied by nourishment. The two may be combined with the greatest advantage; and as the system rallies, stimulants are gradually withdrawn.

Where there has been considerable loss of blood, the demand for nourishment is much more immediately urgent, and must be more abundantly supplied in the most assimilable forms. In this case reaction is longer delayed and more gradually developed. [Patients, who have sustained profuse hemorrhage, usually drink large quantities of water, as though it were required to replace the fluids lost by the escape of blood. Is it not possible that saline solutions would be even more acceptable, and perhaps beneficial?]

I cannot resist transcribing the following remarks by Travers, in his work on

Constitutional Irritation, with reference to this great question:

"If we neglect to supply stimulus when called for, the spark of life goes out. The signs of its indication must therefore be vigilantly observed. We are maintaining action upon inadequate power, in the hope that the natural resources may come to our relief, and that we may gradually diminish stimulus and increase nutriment, which is our only method of raising power to a balance with action.

"The respondence of the circulating forces to an increased supply of stimulus must serve as a caution against over-supply. Since power is deficient, we must carefully husband our only resource, and not waste it in inordinate action. When the signs of reaction are manifested, its excess is much to be apprehended, if such reaction has been obtained by over-stimulation.

"Excessive reaction so induced is 'prostration with excitement' in its most perilous form. When such a state is the original form of the malady, it is probably less dangerous, because in this case the inequality between power and action is less."

If from injudicious treatment, or otherwise, reaction becomes excessive, we have the condition previously described—"prostration with excitement." In this case the indications of treatment are clear and simple enough, but unhappily most difficult to fulfil: to support and increase power, and to moderate and reduce action. We would rather give nourishment than stimulants, but unfortunately the latter are generally necessary and cannot be spared.

When the stomach is irritable and rejects its contents—a common and untoward complication—small pieces of ice, swallowed from time to time, are usually most grateful to the patient and beneficial in their effect. [Iced champagne and effervescing waters are very grateful to the patient.] Mustard-plasters to the epigastrium are also frequently useful; and if not, possess the great merit of being harmless.

Mental excitement may be often moderated by keeping the head cool. The beneficial effects of sleep are never more strikingly seen than in cases of this kind. A few hours of sleep will sometimes altogether change the condition of the patient. Unfortunately, in proportion as it seems needed, it becomes most difficult to procure it. In the worst cases, the absence of sleep is a striking feature. But full doses of opium will often accomplish this desirable end; and it is when opium thus acts that it proves most signally serviceable.

It is the most valuable of all drugs in this condition, and the system will generally tolerate and require unusually large doses. If the patient cannot or will not swallow, it may be given by the rectum. Dupuytren preferred this way to the other of administering it.[1] Or, what in the majority of cases is best, a solution of morphia may be injected under the skin. As a very general rule, it may be said that opium proves beneficial in proportion as the symptoms of syncope predominate. It is contra-indicated when those of coma appear.

When opium fails or disagrees, henbane will often prove a very valuable remedy, or they may be given together. "There is a charm in its operation altogether peculiar." It "soothes and stills." [Chloral and bromide of potassium are valuable adjuncts to the narcotics.]

Concerning the treatment of deficient reaction after injuries or operations there is little to be said. The earliest evidence of failing power, either in the state of the pulse or the temperature of the surface, must be met by support in the form of assimilable food, and, if necessary, by stimulants. Hemorrhage, according to its extent, will delay and impair reaction. Perhaps it sometimes happens that healthy reaction, which in the course of nature should succeed an operation or injury, is for a time averted or altogether destroyed by a depletory plan of after-treatment, adopted with an idea of preventing inflammation, or some one or more of the many ill-defined and as little understood evils associated with that term. While all goes on well, beyond giving a sufficient amount of support in a light and simple form at first, the less that is done the better. Should reaction fail, stimulants must be added to the requisite extent, their effect upon the system being carefully watched. Of the indications for their use Mr. Vincent says, in his Observations, "If in twelve hours, or earlier, the pulse does not indicate increased action, if it becomes fluttering and unequal; when the surface does not seem to evolve heat; when the countenance is listless, and, perhaps, when the patient reports himself better than it might be expected; and particularly if he is not clear in his answers, but is wavering—then that best of all stimuli, brandy, must be thrown in, and if there be delirium, opium." If the stomach prove irritable, as it often will in these cases, ice and mustard-plasters, as previously mentioned, will be, I think, serviceable. Sleep must be obtained; and morphia, with or without some stimulant, will generally procure it.

Both deficient and excessive reaction indicate want of power. They are equally evidence of debility. The circumstances of the case determine which shall for the time prevail. The one condition very commonly passes into the other.

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[1] Leçons orales, t. i., p. 187.

Inasmuch as the shock to the system is, under all circumstances, an evil in proportion to its extent, it behooves us in every case, where it cannot be altogether avoided, to lessen its operation to the utmost. It is to be remembered that, concurrent with the shock of a severe operation, there are many added impressions, all tending to produce a similar effect. For instance, in many cases there is, besides a total alteration of diet, a sudden change from activity to close confinement. This is, as we have seen, sometimes of itself sufficient to induce extreme prostration. Under any circumstances it is a matter of great moment. Travers tells us that his friend Mr. George Young was accustomed, where he could, to get over this difficulty beforehand. He would "impose restraint before the performance of operations requiring confinement, with excellent effect. Having to extract a cartilage from the knee-joint, he would keep the man for a week prior to the operation in the same position that was to be maintained for the week subsequent to it. Thus the irritation of confinement, as well as that of motion, was avoided." And in a case related: "This confinement of the limb occasioned a restless night, some fever, a whitish tongue, quickened pulse, a little headache, spare and high-colored urine."

Certainly in all "operations of expediency," and in others too that will admit of it, this plan is well worthy of adoption. It costs so little, and may save so much.

Moreover, from the evidence before us, it is clear that, prior to an operation, the state of the mind as well as of the body should be carefully investigated; and if an unfavorable condition cannot be corrected, it should be allowed due weight in determining the question of an operation. And on this account, when an operation is decided on, it is unwise as well as cruel to delay or postpone its performance without some good and weighty reason, for doubt and anxiety draw largely upon the health and strength.

These and similar matters are never trivial and of little moment, for they are always more or less influential in determining the issue.

Supposing a person in a state of extreme collapse from a severe injury, the crushing of a limb, for example, and a capital operation, such as amputation, to be necessary, the operation should be performed so soon as the patient's condition will admit of it. Although it would be highly hazardous to operate while the prostration is extreme, yet it is not necessary or even advisable to wait for complete reaction. How far the patient should be allowed to rally, and when he has reached that state which will enable him to bear the operation, are of course questions which cannot be answered in a general manner, but which must be decided by the surgeon in each case. Yet it is to be borne in mind that the immediate impression which an operation makes on a system already under the influence of a shock is considerably less than under other circumstances. It is said: "The shock of the injury covers and identifies with itself that of the operation promptly performed." Of course, so far as the effect of the operation alone is concerned, it would be safer to wait until the system had entirely recovered, if it could do so, from the previous impression; but as valid reasons are opposed to this delay, and we are compelled to inflict an additional injury on a system already depressed, it is very important to be fully cognizant of the fact that the shock of an operation, in such a condition, will be reduced to a minimum.

It is sometimes stated that an operation performed under these circumstances does good by arousing the system. *Similia similibus curantur.* It is certainly true that it will sometimes produce a temporary display of action; but, be it remembered, always at the expense of that power which is already so exhausted. Of all means of exciting action this is certainly the least economical.

In such extreme cases the use of chloroform, as a rule, is not admissible, or at any rate not advisable.[1] Although doubtless, under ordinary circumstances, it considerably mitigates the shock of an operation; yet in these cases, as just stated, the shock is already greatly reduced, and chloroform cannot be safely administered to a patient so depressed. More than once I have watched the feeble and irregular pulse altogether disappear as chloroform was inhaled, and revive again when it was discontinued. Moreover, the grand reason for its employment is wanting; for a person in a state of collapse, from the great exhaustion of the functions of the nervous system, is scarcely conscious of pain.

[In the treatment of shock there is much diversity of opinion regarding some of the methods detailed, but as to the general line of management, surgeons are not greatly at variance. Gross does not believe in bleeding, and Ashhurst looks upon it as an extreme remedy to be used only when death is imminent from cardiac and venous engorgement. Furneaux Jordan does not seem to have been im-

[1] There is, however, some difference of opinion on this point. See the carefully written essay on "Shock," by Mr. Furneaux Jordan, British Medical Journal, 1867, vol. i., p. 282.

pressed with its importance; though on the other hand Dr. B. W. Richardson has referred[1] to cases, which he believes were greatly benefited by its adoption as the line of treatment.

In regard to opium the general verdict is in its favor, since the rest from excitability and the sleep so induced are important restorative processes. In coma, however, it should be avoided, and in brain injuries given with caution. Longmore, however, takes an opposite view, which as a general statement is, I feel, opposed to that usually held by the profession. He says, "On no account should opium in any form be administered to a patient in a state of extreme shock or severe collapse; even a minute dose under such circumstances may lead to a fatal result.[2]

Among the drugs used for the production of reaction are coffee, quinine, digitalis, belladonna, and ammonia. These may be given by the rectum or hypodermically if there is danger of producing vomiting; and can readily be combined in either method with alcoholic stimulus. Digitalis, ammonia carbonate, and whiskey given hypodermically, are favorite remedies with me in severe shock, and I feel that I have seen excellent results from them in some cases where recovery, and in others where death, finally occurred. Ether hypodermically has also been recommended.

One of the most important of all agents to combat shock is heat, and its propriety is evident when we study the symptoms of the condition. An inefficient mode of application in severe shock is to place bottles or cans of hot water about the patient. This is the plan usually adopted. I have even known a heavy can to be laid across the collapsed patient's abdomen, which of course by its weight interfered with respiration. Dr. C. T. Hunter, of Philadelphia, has obtained good results by the hot-water bath, in which the patient is placed, and the temperature of the water rapidly increased from 98° to 110°. The hot-air bath is ably advocated by Mapother, who acts on the theory that the spasmodic contraction of the minute arteries existing in shock is most certainly relaxed by heat. He advises turpentine frictions and enemata, and artificial respiration, if demanded, to be administered while the patient is subjected to the hot air. The heat and the artificial respiration certainly seem well adapted to redistribute the blood engorging the internal viscera. Dr. Levis, of Philadelphia, has recommended copious rectal injections of hot water, as a means of applying heat.

Whichever method is most accessible, should be adopted instantly in all cases of profound shock, for that heat is an essential all are agreed.

Stimulants are usually recommended and employed in the treatment of shock, but undue amounts are frequently given by over-zealous attendants, thus causing vomiting and secondary depression. It should be remembered that most injured patients are given alcohol in some form by those present at the time of the accident; and that many such persons receive their injuries while under the depressing influence of intoxicating beverages. Mr. Savory's remarks on the necessity of discrimination in the administration of stimulants are exceedingly apt.

The extreme views of Dr. J. T. Hodgen, of St. Louis, who rejects alcohol in treating shock, are not held by many American surgeons, but they deserve consideration as coming from a surgeon of great experience. At the meeting of the American Medical Association in 1873, he expressed his opinion that the use of stimulants in shock was bad practice and founded upon a false theory. It has been his custom for many years to treat shock from railroad and gunshot injuries by absolute rest, without stimulants; and he states that his success is greater than it was formerly before he adopted this plan.

Opinions as to the advisability of anæsthesia in operations during extreme shock may differ, but not in the cases usually presented to the surgeon. The majority of surgeons wait for evidence of beginning reaction before attempting amputation in cases of railroad crushes, and then there is, it appears to me, no doubt as to the propriety, nay the necessity, of anæsthesia. Ether increases the force of the heart, and is more desirable than chloroform, but anæsthesia from some agent is requisite to avert pain and diminish the shock of operation. If amputation is done during the stage of profound shock, which is hardly the practice of many operators, anæsthesia may not be required, since the patient is too near death to feel pain. If he feels pain, anæsthesia is demanded at once.

Some surgeons employ a mixture of alcohol, ether, and chloroform in varying proportions, to produce anæsthesia and avert nervous depression. Others have employed chloroform and nitrite of amyl together in a somewhat similar manner for like reasons.

The prevailing opinion of the profession is that it is better to wait for partial reaction, or at least for evidence that reaction is about to take place, before operating on cases of severe crushing of limb

[1] Medical Times and Gazette, ii., 1874, p. 229.

[2] Gunshot Injuries, p. 313.

accompanied by profound shock. Dr. J. T. Hodgen, previously mentioned, is said[1] to incline to immediate operative interference after railroad crushes and similar injuries. Those who believe in the frequent occurrence of delayed shock, favor as a rule immediate amputation in such cases as those described.

In operations for chronic disease and in conditions that will admit of delay and preparatory treatment, measures should be adopted to lessen the shock liable to occur after the operative interference. Reference has been made to this subject by Mr. Savory. There has been proposed by Dr. Levis, of Philadelphia, the progressive method of amputating as it may be termed; which would appear to be valuable in amputation of the thigh and disarticulation of the hip-joint. He proposes to divide the operation into stages, in order to lessen the shock of such serious procedures. At first, for example, the main nerve-trunks should be exposed and divided by means of simple incisions. After these wounds had healed, the arterial trunks should be ligated in continuity above the seat of the proposed amputation. Finally, after the nervous and blood supply of the limb had been thus diminished, the third operation, consisting of the division of the skin, muscles and bones, would be undertaken, and the amputation completed. This method, as far as I know, has not been adopted, but it seems feasible and rational, though if shock depends entirely on the sympathetic nervous system, it is likely that progressive amputation would not diminish shock as much as would at first seem probable.

On all occasions when it is possible, the patient should be prepared for operations of expediency by proper diet, quinine, and other tonics, with stimulants or depletants, according to indications. The mere change from home to a hospital or boarding-house will often prejudice a patient's condition, on account of the surroundings being unusual and the faces and actions of the new attendants unfamiliar. Time should always be allowed for the man or woman to get accustomed to these changes.

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SCROFULA.

By William Scovell Savory, Esq., F.R.S.,

Revised by John B. Roberts, A.M., M.D.

Scrofula is, in one respect at least, an unfortunate word, for it is not clearly defined. On the contrary, very different significations are attached to it. It has certainly become a vague term, so that wherever met with, it is necessary to refer to the context to obtain an idea of the sense in which it is employed. For example, by some it is applied to a certain state of the constitution, and by others to the disease which results from it. Again, it is often applied to all the diseases which,

[1] Richmond and Louisville Med. Journal, Dec. 1878, p. 540.

arising in a certain state of the constitution, possess some general features in common; while it is sometimes limited to the absolute deposit of tubercle, being simply synonymous with the more modern phrase tuberculosis. Finally, the confusion reaches its climax by the introduction of the adjective scrofulous, which is, and perhaps ought to be, if used at all, employed in the same sense as the substantive, but is applied more frequently, at least in conversation, as a less definite term to doubtful cases, when the features are obscure and the diagnosis uncertain.

Some great authorities, indeed, draw a distinction between the tuberculous and scrofulous diathesis, attributing to the latter leading pathological tendencies other than the formation of tubercle—such as attacks of what may be called low or chronic inflammation, in certain parts—and consider the two classes marked respectively by the characters enumerated on page 166. But although there may be, and no doubt is, difference in the degree to which a tendency to the formation of tubercle exists in the two cases, it appears to me that there is nothing sufficient to warrant the pathological distinction which it is now the fashion to make between scrofula and tubercle.

[The confusion existing in the use of the terms struma, scrofula, and tubercle will be appreciated, when the views that are held by different writers concerning them are but mentioned.[1] They are considered identical by some, while others look upon struma as a general term embracing scrofula and tubercle; again, there are pathologists who consider scrofula and tubercle as distinct processes, and others who attempt to trace all scrofulous affections to remote syphilitic parentage.

Billroth speaks[2] of the lymphatic diathesis or scrofulosis, and the tuberculous dyscrasia or tuberculosis, as if he considered them separate causative agents in the production of chronic inflammations. His description of the usually entertained conception of the term scrofulosis is, I think, very comprehensive. It is "a disposition to chronic inflammation of the membranes, bones, and joints, in which the inflammatory process may lead to the development of granulations, suppuration, and caseous degeneration;" and "individuals are very commonly called lymphatic or scrofulous, in whom swellings of the lymphatic glands, even if resulting from temporary irritations, run on for a long time, or even increase independently of any fresh peripheric stimulus." He believes that experimental investigation has proved that tubercle is only a peculiar form of the inflammatory new growth; and this would doubtless lead him to appreciate its close relationship to scrofulosis.[1]]

It is necessary to state, then, that in these pages, by the term scrofula is understood a certain disease or defect of the constitution in which there is a tendency to produce and accumulate a substance called tubercle in various tissues and organs. Tubercle may therefore be said to be the essential element of scrofula.

But it does not follow from this definition that a formation of tubercle must necessarily occur in every case of scrofula. That depends upon the extent of the affection, and is determined by various circumstances.

The use of the word in this comparatively restricted sense possesses at least this merit: it gives precision to the term and renders it definite. But it may be said, Then why not make it at once synonymous with tubercle? that would be yet simpler. True; but then some term would still be required to express the state of the system, and none, as matters at present stand, would be so convenient as scrofula.

Scrofula, or struma (which is a synonymous term), is therefore generally identical with tuberculosis; the use of the latter term however, being often restricted to the case in which tubercle actually exists.

What, then, is tubercle, the essential element of the disease? Its characters, as generally recognized, may be thus described: Tubercle in its strict sense is a substance not vascular, or at least possessing no bloodvessels proper to itself. It has extremely little, if any, inherent power of growth, but beyond all other structures, perhaps, tends to early degeneration. It is either produced in distinct masses of very small size, which may remain separate or rapidly coalesce, or it is infiltrated through various tissues.

Tubercle is usually described as occurring in two principal forms.

It is perhaps more frequently seen as an opaque substance of a dull pale-yellow color; sometimes tolerably firm, yet friable like cheese; at others, softer, like putty, readily yielding to pressure and smearing the surface on which it is pressed; either accumulated into a distinct mass varying in size from a pin's head to a small orange, or else occurring as an infiltration.

But very often it appears in the form of small granular bodies, varying in size from a mere speck to that of a millet-

[1] Ashhurst's Surgery, 2d ed., p. 415.

[2] Surgical Pathology and Therapeutics. Syd. Soc. Ed., vol. ii., pp. 105, 110.

[1] Ib. p. 116.

seed, or occasionally larger; of a pale-gray tint, translucent, and glistening. The more transparent ones sometimes reflect or refract the tint of the surrounding tissues. To a superficial inspection they appear spheroidal, but when more closely examined, they are seen to possess sharp angles; the circumference is more or less irregular, with short branching processes. Thus intimately connected with the adjacent tissues, they cannot be distinctly isolated. They are always firm, and sometimes hard; the cut surface has very much the appearance of cartilage; they yield little or no fluid when crushed; they tend to accumulate in groups.

The first of these forms is distinguished as the yellow, and the last as the gray, or from its ordinary size as the miliary tubercle. Between these two cardinal forms any intermediate variety may occur.

The shape which a mass of tubercle assumes is doubtless due to the influence of the parts around. Its name is derived from the fact that it often possesses a tuberiform shape, although Dr. Carswell has shown that this is less common than had previously been supposed. It is seen most frequently in the brain, and also in the cellular tissue. But it may occur in layers, as in serous membranes, or ramiform, as in the bronchi. In short, its shape is determined by the mould in which it is cast.

In truth, tubercle is most frequently infiltrated into the natural tissues; and although the term infiltration is commonly applied to the diffuse form alone, even the circumscribed masses with definite though generally irregular outlines are, as Paget says, equally infiltrated among the natural tissues, only in these the infiltration occupies a defined area.

Hence the reason why a mass of tubercle, although in itself strictly homogeneous, yet often appears otherwise to close observation. Distinct lines and streaks are frequently visible throughout its substance. These are due to some of the tissues of the organ which become inclosed by the deposit of tubercle as it accumulates. In this way bloodvessels and all kinds of structures may be found in a mass of tubercle; and the tissues thus inclosed sooner or later degenerate or undergo other morbid changes.

As a general rule, it may be stated that tubercles which are most regular in shape, spheroidal or tuberiform, as tubercles in the brain, are most uniform in aspect and structure.

A large and irregular mass of tubercle may arise either from continued deposition around a single centre, or by the coalescence into one of several distinct masses. Tubercles in the lung especially illustrate the latter mode, when of any considerable size.

It has been disputed whether tubercle is ever encysted. With reference to this question Walshe says: "We have ourselves never seen encysted tubercle in any structure of the body, if by the term be understood tubercle contained within a cyst, which has acted as its formative organ. But we have seen in very rare instances in the lung, and, comparatively speaking, somewhat more frequently in bone, tuberculous matter surrounded by a more or less complete membrane, strongly assimilable in properties to the pyogenic membrane of abscesses, and, like it, obviously formed consecutively to some at least of the matter it invested. Such we believe to be the key to the comprehension of 'encysted tubercle.'"

The minute structure of both forms of tubercle is essentially the same. They differ principally in the condition and the relative proportion of the different elements.

To the microscope tubercle exhibits various forms. These may be separated into those that are proper to the tubercle itself, and those which are incidental or accidental and derived from the surrounding parts.

As the elements proper to tubercle may be recognized: Shapeless fragments; flakes or shreds of a substance which is sometimes, as in gray tubercle, transparent and almost homogeneous or delicately fibrous; sometimes, as in yellow tubercle, obscurely granular. It swells and becomes more transparent when treated with weak acids or alkalies:

Innumerable and extremely minute molecules and granules, especially abundant in the yellow tubercle, and in it mingled with oil-globules of various size; these are soluble in, and may be abstracted by, ether, and recovered by evaporation:

Corpuscles or cytoblasts of various shapes and contents, but almost all distinguished by being more or less irregular in form. They are for the most part shrunken, wrinkled, withered, and appear like defectively-developed, aborted or degenerate exudation-cells. Their contents are generally granular, and now and then something like nucleoli may be discerned in their interior. These corpuscles occur in both kinds of tubercle, but those in the yellow variety are much more deformed and distorted, and their contents are more granular.

In addition to these there are found incidentally: ill-formed epithelial cells in all stages of development and degeneration; masses of pigment; crystals and plates of cholesterine; remnants of inclosed and disintegrating tissue, as, for

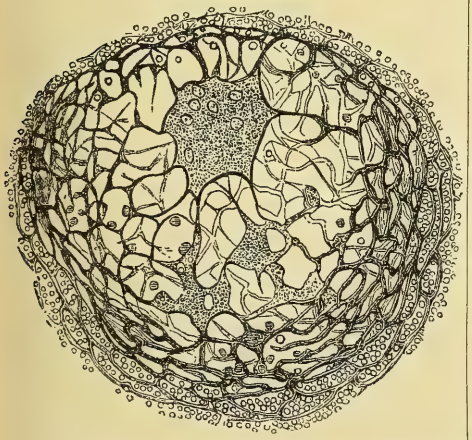
instance, in the lung fragments of elastic fibre, and rarely small bloodvessels in a state of fatty degeneration.

[The histological nature of tubercle has been studied with great earnestness of late years, and the results of this study may be summarized somewhat as follows: A kind of adenoid structure is observable,[1] which consists of small spheroidal cells similar to lymph-cells, separated by a homogeneous transparent material, or by a fibrillated reticulum which may be nucleated and contain within its meshes groups of these cellular elements. Largercells containing one or two nuclei may sometimes also be seen. Myeloid, or large multinucleated cells are usually discovered along with the lymphoid elements. These were especially studied by Schüppel, whose researches led others to pursue a similar line of investigation. They are large, with an irregular outline, without a limiting membrane, and contain many nuclei, which have nucleoli. These multinucleated cells have in many instances long branched processes, which form meshes. It is this network of branched, many-nucleated cells with the associated adenoid or lymphoid structure that seems to be characteristic of tubercles.

Fig. 18.

A portion of a gray miliary tubercle of the lung.

Fig. 19.



Multinucleated and branched cells from a firm gray miliary tubercle of the lung.

According to Green[2] these myeloid cells appear to be simply the result of chronic inflammation, when the new elements are of such low vitality that they are not capable of forming adenoid or fibroid structure. Such cells are most frequently found in tuberculous lesions, but are not especially characteristic of a particular kind of morbid change, and have been discovered as the result of inflammatory processes in various regions of the body. The microscopical appearance of tubercle, it must be remembered, is subject to some modifications depending upon the histological character of the organ in which it is located.]

Tubercle has of course been subjected to chemical analysis, and, in some instances, with very elaborate results. Amongst other substances, it yields, as would be expected, oil, nitrogenous principles, cholesterine, chloride of sodium, phosphate and sulphate of soda, phosphate and carbonate of lime, magnesia, etc.

As already indicated, tubercle possesses very little or no inherent power of growth. It increases simply by the addition of new matter upon its exterior, or by the gradual coalescence of distinct deposits.

Tubercle when deposited may undergo various changes.

In the first place, can tubercle, when once deposited, be simply reabsorbed? This question would be doubtless very generally answered in the negative. Walshe, however, says that his belief in the occurrence of such reabsorption is firm; and Virchow believes there are rare cases in which tubercles, in consequence of undergoing complete fatty metamorphosis, become capable of absorption: but, although there is assuredly no reason for denying its possibility, the evidence advanced in its favor is yet far from conclusive.

[In speaking of pulmonary consumption, Niemeyer avers[1] that absorption of the cheesy deposits through fatty change and subsequent liquefaction may be so complete that not a trace of caseous material can be discovered, and nothing will be found on close examination but lung structure indurated from intestinal pneumonia, and changes usually occurring during the progress of this cirrhotic process.]

Yellow tubercle, after it has remained firm for a variable period—the crude tubercle, as it is called—has a strong tendency to soften. This, in the majority of cases, sooner or later occurs. The process of softening may commence in any part of the mass, and may be either of intrinsic or extrinsic origin. There appears to be no doubt now that the change is sometimes, perhaps usually, intrinsic—a form of natural degeneration, such as may occur in lymph, and by which the

[1] Introduction to Pathology and Morbid Anatomy. By T. Henry Green, 2d Am. ed., p. 184.

[2] Ibid.

[1] Practical Medicine. Revised Am. ed., 1880, vol. i., p. 218.

softening of fibrinous clots within the heart and veins is effected. Indeed, as exceptional cases, tuberculous coagula sometimes form within the bloodvessels. This process of spontaneous softening usually commences at or near the centre of the mass, "in the part of it which, we may believe," says Paget, "being most remote from the blood, is least able to maintain itself in even such low development as it may have reached." When a tubercle undergoing this change is divided, the softened portion, glutinous, tenacious, fatty, is readily distinguished. It may be pressed out from the firmer portions. As the change proceeds, softened caseiform flocculent fragments float in a thin, yellowish, turbid fluid. By and by the whole may become liquid.

In the liquefied matter corpuscles may still be detected in advanced stages of degeneration, amidst an abundance of molecules and globules of oil. Under these circumstances the large granule-cells appear. The principal changes are the disintegration and destruction of the corpuscles, and the abundant increase of oil-globules. It is fatty degeneration.

But the softening may be of extrinsic origin, and, as it were, accidental. In this case it is due to "the mingling of liquid products of inflammation in the adjacent tissues." Softening from this cause usually commences at the periphery, but sometimes in the central portions, when the natural textures are there inclosed. Pus then becomes mixed with fragments of tubercle.

The liquid thus produced is usually discharged by ulceration of the investing tissues, or it may be retained. The fluid portion is then slowly absorbed, and it dwindles into a putty-like mass, which still further shrinks and hardens.

When the disintegrated tubercle is discharged, either an ulcer or a cavity is produced. In this way vomicæ in the lungs are commonly formed. And these may be extended "through communications formed with softening tubercle on their confines."

[Sometimes the retrograde metamorphosis does not go on to such general fatty disintegration, but the nodule becomes more fibrous in its consistence, and is converted into a dense fibroid mass, which in time, however, may undergo caseation. Green believes that the greater the irritation the greater is the tendency to softening; and the less irritation and the more chronic the process the greater is the probability of the fibroid change.[1] This metamorphosis occurs more frequently in the miliary form of tubercle.]

It is stated that tuberculous matter is sometimes, though rarely, exuded from the surface of certain mucous membranes without any breach of texture.

[Usually, however, the tuberculous process is consecutive to some previous inflammation that has caused ulcerative breaches of surface. Then tubercles develop in the floor of the ulcer, and especially in the vicinity of the bloodvessels.]

Yellow tubercle may undergo what is termed calcareous degeneration, and this even after it has begun to soften. The corpuscles shrivel and wither. The organic matters gradually disappear by absorption, until scarcely a trace remains, and nothing but a cretaceous mass composed of inorganic salts is left behind; and this may be, but is not often, finally expelled. Such cretaceous fragments are sometimes expectorated.

The gray tubercle may also undergo a peculiar degeneration or withering. Rokitansky thus describes it: "After abiding in the primitive crude condition before described, it becomes transformed, with the loss of its moisture—with condensation—to a hard nodule, and shrivels into a tough, amorphous or indistinctly fibrous, horn-like mass—in a word, *cornifies*. This determines a complete wasting and death of the tubercle, subversive of all further change. Occasionally this process is associated with bony deposition, the tubercle becoming a partly cornified, partly ossified nodule." He adds: "this tubercle does not undergo any other metamorphosis independently."

But it is now generally accepted that the two forms of tubercle, the gray and the yellow, represent different stages or degrees of the same disease. The gray is regarded as an earlier condition of the yellow tubercle. This opinion is based upon the following evidence.

As already described, they exhibit essentially the same structure. It is true that the different elements vary in their relative proportion in the two forms, the corpuscles predominating in the gray, and appearing more normal in character, less degenerate; and the granular and molecular matter being much more abundant in the yellow: but this is a question of degree merely, not of kind, and when considered, constitutes a strong argument in favor of the view.

The gray and the yellow tubercle are often found mingled together. And further, the yellow tubercle often appears in the substance of the gray, and is believed gradually to take its place; and this transformation may be seen in all degrees of progress. Even Rokitansky admits "the combination of the two cardinal tubercle-blastemata in different proportions, and their manifold grades of co-ordination and of blending." Speaking of the degenera-

[1] Op. cit., p. 185.

tion of the gray into the yellow tubercle, Williams says: "Generally the change begins in the centre of the mass, apparently because, there being no permeating vessels, the centre is the furthest removed from the vivifying influence of the blood." This explanation has been also applied, as previously mentioned, to the central softening—the further degeneration of yellow tubercle.

But it does not follow from this that the deposit of yellow tubercle is always, as some maintain, preceded by the gray. On the contrary, in some organs the gray is very rarely seen; in the brain, Walshe says, never. And sometimes yellow tubercles are discovered of the minutest possible size, without any trace of gray substance. Virchow and others, however, regard the gray miliary granule as the typical form of tubercle, and the yellow as the same in a state of fatty degeneration.

[Though miliary tubercle is the original source of some masses of caseous deposit, or yellow tubercle, yet all cheesy depositions must not be regarded as due to fatty degeneration of gray tuberculous matter. Caseous change, technically called tyrosis, may occur in purulent, cancerous, and other deposits; and hence there may be "yellow tubercle," if this term be retained, that is directly inflammatory in its origin without reference to an intermediate gray stage. These cheesy masses are readily developed in the rabbit and some other animals by any inflammatory irritation giving rise to suppuration; and have thus added much confusion to the already entangled subject of tuberculosis. Although these inflammatory caseous masses are not developed from gray tubercle by fatty metamorphosis, they have a relationship to gray or miliary tubercle; since tuberculosis, or the deposit of gray tubercle, is produced by a species of self-infection of the human subject from a depot of cheesy matter in some part of the organism. Experiment has shown Waldenburg that tuberculosis in animals, though caused at times by any irritant, is most certainly produced by inoculation with cheesy material, whether taken from gray tubercles undergoing caseous change or from inflammatory pneumonic products undergoing similar metamorphosis.[1] Any caseous depot, however, whether in knee-joint, shaft of bone, or elsewhere, may have a similar etiological connection with the tendency to tuberculous deposits in the human subject.]

With regard to the relative frequency of tubercle in the various textures and organs, I will quote Rokitansky, for his statistics are unrivalled. He gives the following scale:—

In adults: lungs; intestinal canal; lymphatic glands, more particularly the abdominal and bronchial; larynx; serous membranes, especially the peritoneal and pleural; pia mater; brain; spleen; kidneys; liver; bones and periosteum; uterus and Fallopian tubes; testicles (including the epididymis), with prostate gland and seminal vesicles; spinal cord; striated muscles.

In children: the lymphatic glands, together with the spleen, would take the lead, followed by the lungs, with the bronchial mucous membrane, the brain, the serous membranes, etc.

But this list includes all formations, whether primary or secondary. A more important question still remains to be answered. In what organs is the primary deposit of tubercle most frequent? Where is tubercle most likely to be deposited in the first instance? I refer again to Rokitansky. "If, which is most important, we consider tuberculoses individually, according to their primitive or to their secondary appearance, an entirely different scale is set up. The lungs and lymphatic glands, it is true, retain their uppermost rank, but are immediately followed by tuberculoses which stand very low in the foregoing scale, namely, of the urinary system, of the female sexual mucous membrane, of the bones, of the testicles, with the prostate gland and the seminal vesicles. Meanwhile tuberculoses of the intestine, of the larynx and trachea, of the serous membranes, of the spleen and liver, take a very subordinate position in the new scale, seeing that they seldom, if ever, become the primary seat of tubercle. Tuberculosis almost invariably attacks several determinate organs concurrently at the outset, or at a very early period."

With regard to the tissue in which tubercle is deposited, he says: "The seat of tubercle, as an exudate, is, at any point of any texture, extraneous to the bloodvessels. Wherever there is a capillary range, a deposition of tubercle is possible. The seat of tubercle is without doubt precisely, or at least in close proximity to, the spot of its exudation, its blastema being in the highest degree coagulable. It is most probably for this reason that it does not affect textures nourished from a distance by slow imbibition of their substance with plasma, for example, cartilage. We can ourselves testify to the occurrence, both in the larger bloodvessels and in the capillaries (as depots or metastases), of coagula obviously of a tuberculous nature."

It is worthy of note that tubercle has

[1] Waldenburg, Die Tuberculose, die Lungenschwindsucht und Scrofulose. See Review, by J. C. Reeve, in Am. Journal Med. Sc., Jan., 1870, p. 165.

generally in every organ some favorite part, some portion especially disposed to the deposit. For example, in the lungs it usually commences at the apex; in bones, in the spongy ones, or in the cancellous texture of others. In some of the cases it is perhaps possible to account for the selection.

What is the nature of tubercle? This great question, second to none within the whole range of pathology, so often asked, so often replied to, yet remains a doubtful one. The highest and best authorities are still at issue concerning the nature of tubercle.

Is it a specific product, and should it be classed with the same order of diseases as cancer? Is it the product of inflammation? Is it composed merely of the elements of dead tissue? Is it a peculiar transformation of tissue-elements co-ordinate with fatty and the allied degenerations? Has it always an origin from the cellular elements of connective tissue? Is it ever formed by the increase and metamorphosis of epithelial cells analogous to the process of glandular secretion, or rather as a morbid desquamation? Is it simply a degraded condition of the nutritive material? These questions might be multiplied.

The grand argument in support of the opinion, that tubercle is a form of degraded plasma, or, more specifically, degenerate lymph, which assumes the hitherto generally received doctrine concerning exudation to be the true one, is similar to that on which the relation of gray to yellow tubercle, previously referred to, is founded, viz., that all forms and conditions of lymph are met with, from that which is most plastic and susceptible of organization, to that which is most degenerate—the gray and yellow tubercle—and that between these extremes all intermediate gradations are found, so that it becomes impossible to draw a line, which is not an arbitrary and artificial one, at any point, and say that it separates lymph from tubercle.

Nay, more; this gradual transition may be seen even in a single deposit. Rokitansky says, "just as tubercle-blastemata combine with one another, so, in like manner, does organizable blastema enter occasionally into combination with tubercle." And, further, as would be expected, "the combination of gray tubercle with organizable fibrine is more susceptible of proof. The instances are not rare in which, hard by pure gray tubercle, granulations are found, in which one portion of their blastema is in progress of organization to a fibrous texture, whilst the other abides in its primitive condition, and eventually falls into decadence —cornifies." Again, Schrœder van der Kolk says rudimentary filaments of newly-formed tissue are sometimes seen among the cells of tubercle.

This holds good even for their minute structure and the elements of which they are composed; as in the two forms of tubercle, it is a question of degree only; the plastic elements predominating in the higher, and the products of degeneration in the lower forms. Paget says: "There are, I believe, no signs by which degenerate lymph or pus may be, in all cases, distinguished from ordinary tuberculous matter. A distinction of degenerate lymph from tubercle may be impossible."

The same statement also applies to the changes which the deposits subsequently undergo. Rokitansky and Paget, when speaking of the degenerations of tubercle, frequently compare them to the degenerations of lymph. Indeed, so far as we know, the process is the same.

But on this account tubercle is not to be regarded, as it sometimes is said to be, as an event of inflammation. It does not follow from this that inflammation must necessarily precede its exudation. It may be, and doubtless is, often an exciting cause; but tubercles are frequently deposited without any evidence, either direct or indirect, of inflammation. If the question be asked, What, then, determines the exudation or deposition of tubercle? the answer may be—supported as it is by the authority of Rokitansky—Tubercle, "like other blastemata," may exude insensibly as in the act of nutrition, or as a result of congestion, or as a consequence of inflammation.

But the occasional or frequent connection which exists between inflammation and tuberculous deposit is another fact in favor of the relation of tubercle to lymph. In certain forms of pneumonia the effused matter which produces consolidation of the lung, may have in one portion all the characters of ordinary lymph, and in another the characters of tubercle; and in some of these cases the matter, which cannot be distinguished in any way from tubercle, evidently consists of degenerated portions of the lymph. In different parts this process of degeneration may be traced. A similar condition is frequently witnessed elsewhere. On the other hand, tubercle has no inherent independent power of growth such as tumors possess.

Moreover, tubercle has in its structure no characteristic element which defines it from all other structures. Although Lebert and others have described corpuscles supposed to be distinctive as "tubercle-cells," yet by the great majority of observers these cannot be distinguished from degenerate and deformed exudation corpuscles, such as are commonly seen, under certain circumstances, in effused

lymph. We may therefore speak of tubercle as composed of degenerate and decaying elements.

Dr. C. J. B. Williams—who has for many years regarded tubercle as "a degraded condition of the nutritive material from which old textures are renewed and new ones formed, and that in its origin it differs from the normal plasma or coagulable lymph, not in *kind*, but in *degree*, of vitality and capacity of organization"—divides deposits into three classes. The euplastic; healthy organizable lymph. The cacoplastic; defective in organizability, represented by the indurated tissue which characterizes cirrhosis of the liver and that which occasions the opaque tough thickening of the valves of the heart, and seen again often in the dense cicatrices of scrofulous sores. Into the lowest extreme of this class comes the gray transparent tubercle. The aplastic; which includes all the more common forms of tubercle. These divisions, and the terms employed to express them, are convenient and useful; only it must always be borne in mind that they are in one sense artificial, inasmuch as their limits are not naturally defined. For, as Williams says, "every gradation may be found between euplastic and aplastic deposits."

This view of the pathology of tubercle—its affinity to lymph—which is a very old one, and received many years since the support of Alison, enables us very clearly to comprehend the relation of the gray to the yellow deposit, and to understand how, by a process of still further degeneration, the transformation ensues; and how it happens that so often the yellow form is at once, in the first instance, deposited, the change in this case preceding the exudation. But by Virchow and his school a very different view of the nature and affinities of tubercle has been set forth. The mode of formation of tubercle has indeed been chosen by Virchow as the chief illustration of his great doctrine which is now well known by the name of cellular pathology. According to this view, which utterly rejects the old doctrine of exudation, the essential elements of tubercle—the cells—are the offspring of the cells of connective tissue. This is affirmed of all morbid growths, even of the so-called deposits. Like tubercle, they all arise in connective tissue, and the cells of which they are essentially composed are the descendants, degenerated or variously perverted, of the original connective-tissue corpuscles. Thus it can never be right to speak of a deposition in a part, but always of a new growth from a part.

Perhaps, however, after all, the contradiction involved in these two great doctrines is more apparent than real; or rather it may be said, that while either view fails to expose the whole truth, each reveals an important part of it which the other ignores. The old doctrine takes no heed, or at least offers no explanation, of the changes which the so-called deposit undergoes, while the new doctrine looks no further than the part in which these new formations are found to explain their origin.[1]

[Probably no pathological process has been studied with such earnestness and zeal as tuberculosis; and therefore many discordant views of its nature have obtained advocates and followers. Waldenburg gives an elaborate historical account of the development of the theories of pathologists from the earliest time, but

[1] Within the last few years much attention has been given to the question, whether tubercle can be transmitted by inoculation.

The attempt to propagate the disease by this means is not a new one, but of late numerous experiments have been made on animals, and from these the conclusion has been drawn that tubercle may be thus produced.

In 1865 and 1866 M. Villemin laid before the French Academy of Medicine two series of experiments, to show that tubercle can be transmitted from man to animals by inoculation (Bull. Acad. Med., xxxi., xxxii.). In the latter year Lebert related experiments confirming this result (loc. cit., xxxii.). It was also in the main confirmed by a committee appointed to report on the subject. Similar experiments were performed by MM. Hérard, Cornil, Hoffman, and Genondet, and by Mr. Simon and Dr. Marcet, the latter gentleman proposing to use the sputa of patients as a means of diagnosis of tubercular disease (Med.-Chir. Transactions, 1867).

But then Dr. Andrew Clark found that he could succeed in producing similar results by inoculating animals with other non-tuberculous morbid products. Dr. Sanderson, from numerous experiments, came to the conclusion that morbid changes in internal organs, of the same nature as those resulting from the inoculation of tubercle, could be produced by any irritation of the requisite degree of intensity applied to the subcutaneous tissue, and that experiment afforded no ground for believing in the existence of a tuberculous virus (British Med. Journal, April 18, 1868). About the same time, and quite independently, Dr. Wilson Fox found that non-tubercular substances introduced under the skin of guinea-pigs and rabbits were followed by the production of a disease which he considered tuberculous (op. cit., May 23, 30, and June 6, 1868).

These experiments, then, afford no support to the doctrine that tubercle is a specific disease in the sense in which that term is commonly employed, but tend rather to confirm the opinion which has been advanced in the text.

with the discarded hypotheses we have little to do. The reader, who is interested in the matter, will find an admirable digest of Waldenburg's work in the review already mentioned.[1] The pathological authorities of the present day seem for the most part agreed that tubercle is inflammatory in its nature. Thus Billroth states his belief that "tubercle is only a peculiar form of the inflammatory new growth."[2] Green, in speaking of tubercle, in connection with pulmonary phthisis, requests us to remember that this growth is now known to be an inflammatory one.[3] Niemeyer defines as scrofulous those persons in whom there is a tendency to glandular enlargement, from profuse formation of cells upon the application of slight inflammatory irritation; and calls attention to their great tendency to inflammatory processes.[4] Gross, believing in the identity of scrofulous and tuberculous affections, declares that the process is an inflammatory one; and even goes further in stating his conviction that many so-called cases are really examples of inherited syphilis.[5] Da Costa, however, while not absolutely denying the inflammatory nature of tubercle, seems to doubt it in his statement: "I may be pardoned if I hold fast to the belief that the process, whatever it be, is something special, though something of which we do not hold the key."[6]

Scrofula, in accordance with the inflammatory view, is a condition of the individual in which inflammations give rise to an exudation, composed of a vast number of cells, which become caseous instead of being readily removed by absorption like an ordinary serous inflammatory deposit containing less cellular elements. Both conditions are thus said to be inflammatory, but in the former removal is less easily effected, and caseation with destruction of involved tissues occurs. These cheesy masses, by their absorption, chiefly through the lymphatic vessels, infect the surrounding and distant tissues, and produce these miliary or gray tubercles. This is the view held by Niemeyer and many others, who look upon miliary tuberculosis as an absorption disease originating from the entrance into the blood-current of minute cellular elements which are deposited in the various localities where gray nodules are subsequently found. This process of self-infection then is seen to be similar to the production of metastatic abscesses in pyæmia, and, indeed, Burdon-Sanderson looks upon the two processes as closely analogous.[1]

According to these views, gray tubercle is always acquired, and the inherited element is the disposition or diathesis predisposing to that form of inflammation which is accompanied by great cellular formation, so apt to lead to caseation and secondary tuberculous nodules in the same or other organs.

I must admit, however, that all writers do not fully indorse these doctrines, and I therefore refer to Da Costa as one who believes that caseous pneumonia, for example, leads to tubercle elsewhere, because it is really tubercle already, and who says that it is not the products of ordinary inflammation which infect, but the tubercular products existing in the primary deposits, though perhaps not discovered.[2]]

Are there any signs by which that state of the constitution which tends to the production of tubercle can be recognized? Does scrofula manifest itself by any other symptoms than the deposit of tubercle? Often, very often; but not always. As a general rule, but subject to numerous exceptions, it may be said that the symptoms of scrofula are the symptoms of debility.

Those who have written on the subject have, for the most part, described at length certain characters of body and mind, by which they affirm those persons to be distinguished in whom the disease is likely to be developed: and usually two varieties are depicted.

In the first, distinguished as the sanguine or serous, there is a general want of muscular development; for although the figure may be sometimes plump and full, the limbs are soft and flabby; the skin is fair and thin, showing the blue veins beneath it; the features are very delicate, often a brilliant transparent rosy color of the cheeks contrasts strongly and strikingly with the surrounding pallor; the eyes, gray or blue, are large and humid, with sluggish pupils, sheltered by long silken lashes; hair fine, blond, auburn, or red; teeth white, and often brittle; there is frequently a fulness of the upper lip and alæ nasi; the ends of the fingers are commonly broad, with convex nails bent over their extremities. Such persons usually possess much energy and sensibility, with elasticity and buoyancy of spirits; they often possess, too, consider-

[1] Am. Journal Med. Science, Jan., 1870, pp. 137-171.
[2] Surgical Pathology and Therapeutics. Syd. Soc. Ed., 1878, vol. ii., p. 116.
[3] Pathology and Morbid Anatomy, 2d Am. Ed., 1876, p. 266.
[4] Practical Medicine, Am. Ed., 1880, vol. i., p. 212.
[5] System of Surgery, 5th ed., vol. i., p. 280; and Trans. Am. Med. Assoc., 1874, p. 249.
[6] Phila. Med. Times, June 19, 1880, p. 470.

[1] Ashhurst's Surgery, 2d ed. p. 416, note.
[2] Phila. Med. Times, June 19, 1880, p. 472.

able beauty. In this variety, with the same delicacy, the skin and eyes are sometimes dark.

In the second, distinguished as the phlegmatic or melancholic, the skin, pale or dark, is thick, muddy, and often harsh; the general aspect dull and heavy; hair dark and coarse; the mind is often, but not always, slow and sluggish.

Children especially, in whom the diathesis is strongly marked, are often distinguished by the narrow and prominent chest, the tumid and prominent abdomen, and the paste-like complexion; the limbs are wasted; the circulation languid; chilblains are common on the extremities; the mucous membranes particularly, and, above all of them, the digestive, are liable to morbid action; the breath is often sour and fetid; the tongue is furred, and the papillæ towards the apex red and prominent; the bowels act irregularly, and the evacuations are unusually offensive; the digestion weak; the appetite variable and capricious. In Dr. Todd's opinion, the "strumous dyspepsia presents a more characteristic feature of this habit of body than any physiognomical portrait which has yet been drawn of it." The relation of disorder of the digestive organs—the subject upon which Abernethy was so wont to insist—to scrofula, was many years ago particularly dwelt upon by Lloyd. There is often a singular assumption of age both in character and appearance; in mind and manners they are prematurely old.

Moreover, persons, and especially children, possessing this diathesis, are very subject to certain affections which are regarded by many as manifestations of scrofula. Such, for instance, as various eruptions frequently seen behind the ears; chronic inflammation of the eye-lids and conjunctivæ; a certain form of ophthalmia, described as strumous; chronic ulcers of the cornea, etc.

Now although it is quite true that those who are thus distinguished are especially prone to the production of tubercle, yet it is equally certain that it frequently occurs in others who do not at all correspond to either of these descriptions. In fact, we know of no description of persons in whom we could venture to say that tubercle will not appear, for it belongs to all temperaments. The utmost we can assert is, that in those in whom the characters previously detailed are most strongly marked, tubercle is most liable to occur.

Moreover, some of the characters detailed are so common, that it may be reasonably questioned whether their connection with tubercle is not merely accidental; while of others more decided it may be doubted whether they are not rather the effects of, than antecedent to, scrofula.

[The attempt to define the characteristics, which are presented by persons liable to suffer from scrofulous diseases, has always seemed to me a failure; and this is the opinion of many surgical writers of recognized authority. Paget, in his classic work[1], states that it is difficult to see the common characteristics of many of the so-called scrofulous diseases. Billroth, after giving the familiar book description of a so-called typically scrofulous child, adds that he does not attach much importance to these outward appearances.[2] Our author himself, after detailing the two varieties, so often described, admits that the connection of the scrofulous diathesis with these physical characteristics seems doubtful.

If the theory of tuberculosis, previously stated as being the one generally held at this time, be accepted by the reader, he will not wonder at the unsatisfactory descriptions of the scrofulous diathesis. If tuberculosis is an inflammatory condition, if gray tubercles are produced by self-infection from cheesy deposits, if these cheesy deposits result from inflammatory products, surely every one may become scrofulous or tuberculous. Then every variety of general appearances may furnish examples of the scrofulous "habit;" and the varieties of scrofula will increase from the two mentioned by our author (the sanguine and the phlegmatic) to as many as there are different temperaments in the human family. True, some temperaments may be more liable than others to inflammations giving rise to great cell production, and hence more readily furnish caseous depots; but this does not enable the scientist to predicate which temperament is the unfortunate one.

Those who believe, with Gross, that scrofula means in the majority of cases, if not indeed in all, inherited syphilis, will have still less difficulty in understanding the impossibility of looking upon constitutional characteristics as indicative of scrofulous tendencies. They will rather consider them results than antecedents of the scrofulous disease.

Niemeyer asserts[3] that there is no anatomical sign by which scrofulous ophthalmias or eruptions can be distinguished from similar non-scrofulous affections, and thinks their scrofulous nature is only inferred from co-existing glandular enlargement, insignificance of cause, their recurrence, and obstinacy to treatment.]

Scrofula is a disease of early life. Its manifestations are very common before,

[1] Surgical Pathology, Am. ed., p. 821.

[2] Surgical Pathology and Therapeutics, Syd. Soc. Ed., 1878, vol. ii., p. 107.

[3] Practical Medicine, Am. Ed., 1880, vol. i., p. 212.

and comparatively rare after, the middle period.

[Scrofula is too often looked upon as a disease only occurring in the young, and its manifestations will be seen in the old with considerable frequency, if the surgeon be not prejudiced by a preconceived idea that it is a disease of childhood and young adult life. Paget asserts[1] that he has seen cases of scrofula of lymphatic glands, bones, spine, and testicles in persons over sixty years of age; and that in one instance the patient was ninety-one. Indeed, he believes this class of affections to be more common after 60 than between 30 and 50 years. The diagnosis of senile scrofula rests upon similar symptoms to those found in the juvenile affection, but the existence of gouty and cancerous affections must be eliminated. The treatment is to be conducted upon the same principles, but will of necessity give less beneficial results, since old age is a period of deterioration of constructive metamorphosis.]

Certain persons, then, are more liable than others to a deposit of tubercle, although it is by no means always possible to distinguish such beforehand. Persons in whom there exists this tendency to the formation of tubercle are said to possess the scrofulous or strumous diathesis. Now the great cause of this predisposition is undoubtedly hereditary. It is transmitted from parent to offspring. Scrofula is, perhaps, more frequently transmitted hereditarily than all other diseases together. It does not follow that the parent must have tubercle in order to transmit the diathesis to the offspring, any more than it follows that the disposition or tendency so transmitted must necessarily lead to the development of tubercle. Indeed, many maintain, with Sir James Clark, that "a state of tuberculous cachexia is not the only morbid condition of the parent which entails the tuberculous predisposition on the children; there are several diseases which have this effect: in short, a deteriorated state of health in the parent, from any cause, to a degree sufficient to produce a state of cachexia, may give rise to the scrofulous constitution in the offspring."

Can the diathesis, if not hereditary, be acquired under any possible circumstances? To this very important question it is, from the nature of the subject, almost impossible to give an unequivocal answer. The causes of disease are conveniently and naturally divided into predisposing and exciting or determining, and the development of disease depends upon the extent to which these causes act in combination. For example, by way of illustration merely, let it be assumed that any given disease cannot be produced unless the sum of the causes reaches a certain figure—say a hundred. Now, so long as this number can be attained by the causes conjointly, it matters not what their relative share in it may be. The predisposing cause may equal seventy, and the exciting cause thirty, or *vice versa*. From this it follows, as is well known, that when the predisposition to disease is strongly marked, the most trivial exciting cause may suffice to develop it; it may be ninety-nine to one. On the other hand, if the exciting cause or causes be sufficiently intense and prolonged, the disease may be produced when there is only the faintest predisposition. Now the difficulty of answering the question just proposed lies in this: It can never be said of any person that he has no predisposition whatever, that he is proof against the occurrence of tubercle; for tubercle has again and again appeared in those seemingly the most immune from it. Or again, supposing the subject of tubercle to be born of apparently healthy parents, we do not know that the diathesis was not lurking latently in them, wanting only a sufficient amount of exciting cause for its outbreak. For it is commonly believed that a predisposition may lie latent in a generation or two, and appear in the next; moreover, other diseases of debility than scrofula in the parent may probably develop the scrofulous diathesis in the offspring. In short, the question cannot be answered, because it can never be said of any one that he is proof against tubercle; and when tubercle does appear in any one in whom from his constitution and history we should least have expected it, we cannot be sure that he has not inherited the disposition from an ancestor, immediate or remote, in whom nevertheless it may have been latent. "For there is hardly a family," says Dr. Latham, "into which consumption, sooner or later, does not enter." Practically speaking, however, there are no grounds for denying the fact that the disposition to tubercle may be, when not hereditary, acquired; on the contrary, both reason and experience are in favor of the belief: and even were the evidence less convincing than it is, even were the case more doubtful, it would be wisest to act upon the assumption of its possibility.

[The hereditation of tubercle has been a much disputed topic, and the question is answered in different ways, according to the pathological theories of the respondent. Niemeyer, who may be taken as the exponent of one side of the question, believes that the tendency is in many cases congenital, and when this tendency

[1] Clinical Lectures and Essays. London, 1875, p. 344.

is due to the parents having been consumptive at the time of birth, may be designated hereditary; but "it is not (as is often asserted) the malady which causes the inheritance, but the weakness and vulnerability of constitution which had already laid the foundation of the consumption in the parents."[1] Men and women of deteriorated constitutions from prolonged sickness, debauchery, or old age, are as likely, in this view, as any others, to have offspring born with a predisposition to consumption and other scrofulous affections. In like manner any one, however robust originally, may acquire tubercle, since caseous inflammations are the starting points of the infecting process. The inheritance of tubercle is thus believed to be indirect, and depends upon the inheritance of a feeble habit of body prone to caseous inflammatory degenerations; which cheesy deposits stand in a primary relation to the development of miliary tubercles.

The character of food furnished infants is regarded by many as the cause of scrofula in those where the hereditary predisposition is not tuberculous. Dr. James T. Whittaker has recently laid stress on the fact that children who suffer with tuberculous meningitis are frequently found to have been artificially nourished; and that sometimes the disease has been traced to the milk of tuberculous cows. He considers artificial feeding a frequent cause of this scrofulous affection.[2]

Those pathologists who do not accept the inflammatory etiology of tubercle or reject in part the sequences of the theory, hold that scrofula is in the very great majority of cases, if not in all, obtained by direct hereditation and comes as a legacy from parent to child. The appearance of the disorder in those whose descent seems to be from a non-tuberculous stock, is then attributed to a latent taint, which has perhaps skipped one or more generations.

I must admit that my personal views incline to the theory that tuberculosis is often acquired, though certainly some persons are born with the *tendency* already derived from diseased parentage. The similarity of the disease in many of its manifestations to syphilis, would lead us, even if we do not regard it as remote syphilis, to accept the possibility of hereditary scrofula, and acquired scrofula. Certain it is that the first scrofulous person must have acquired it, and hence why may not others have done so?

[1] Practical Medicine, Am. Ed. 1880, vol. i., p. 213.

[2] Cincinnati Lancet and Clinic, Jan. 1, 1881, p. 8–9.

The contagiousness of at least one scrofulous lesion is now believed by some,[1] who hold that pulmonary phthisis, though not contagious in a high or even in a moderate degree, may very occasionally be transmitted from one person to another by the inhalation of small particles ejected during respiration and coughing. The difficulties of solution of this question are almost insuperable, especially if the doctrine of self-generation of scrofula be admitted.]

Of this, however, there is no doubt, that the tendency to the production of tubercle exists in different degrees in various persons; it may be so strong that no skill or care can avert its development; it may be so slight as only to appear under a combination of the most unfavorable exciting causes. What are these? "They may all be ranked together," as Alison says, "as causes of *debility;*" many of them may be regarded, not as exciting causes merely, but as predisposing ones. The chief are—

Insufficient food and improper diet. Watson, speaking of this cause, remarks: "There is one fact which has always struck me as very instructive and convincing on this point. Infants at the breast, supplied with good milk, and with plenty of it, seldom show any signs of scrofulous disorder; whereas as soon as they are weaned, they become subject to various complaints of a strumous kind. When an unweaned child is brought to us with ophthalmia, we expect almost always to discover inflammation of the common and acute kind—the purulent eye; in nine children out of ten who come after weaning, we look for and find some form of scrofulous inflammation, such as pustular ophthalmia." [Milk from diseased cows has been mentioned above as a cause of tubercular meningitis.]

On the other hand, intemperance and excess.

Impure air, whether simply from want of ventilation, being deteriorated by respiration, etc., or impregnated with deleterious gases and noxious vapors. [Or containing perhaps particles exhaled from scrofulous lungs.]

Exposure to wet and cold, and to sudden changes of temperature. The utmost importance is to be attached to climate. The climate of Great Britain is prejudicial in this respect, perhaps rather on account of its variableness and vicissitudes than from its low temperature, when compared with those regions where scrofula is less common. The influence of climate is shown not only in the improvement which many persons experience when

[1] Am. Journal Med. Sciences, Jan. 1870, p. 168.

they migrate to warmer and more equable ones, but also in the frequent development of tubercle in the inhabitants of those latitudes when they come hither.

Mental depression. Few causes can rival for mischief anxiety, when intense and prolonged.

Of course these causes are more potent when combined. Certain occupations are mischievous, on account of the circumstances to which those who follow them are exposed. Such, for instance, as working for the greater portion of the twenty-four hours in close and ill-ventilated rooms lighted by gas; exposure to noxious fumes and vapors, or to the dust of stone or metal, or to the night-air [?] at all seasons and in all states of the weather, or to great and sudden transitions of temperature; excessive and continued fatigue, whether mental or bodily; poverty, of course, with all the evils following in its train.

Knowing that the causes of debility favor the formation of tubercle, we can understand its frequent supervention when the powers are depressed by some other disease. Where we have any reason to suspect a predisposition to tubercle, we anxiously watch during the period of convalescence from illness of any kind.

[Ulcer of the stomach, and other diseases affecting nutrition, diabetes mellitus, typhus fever, and many of the exanthems, have a tendency to promote the development of scrofulous affections.]

As illustrating the course and local treatment of tubercle, when deposited, the cervical lymphatic glands may be conveniently selected: for of all parts liable to the deposition of tubercle within reach of the surgeon, they hold the first place. In the adult, as we have seen, the lymphatic glands rank next to the lungs and intestinal canal in order of frequency, and in children of all organs they stand first.

Now these glands are sometimes the seat of common inflammation and suppuration, and this may occur even in those who possess the scrofulous diathesis. But this is a rare exception to a very general rule; for when these glands inflame and suppurate, it is usually as the result of a previous deposition of tubercle. I believe that the vast majority of those cases which are spoken of as ordinary inflammation of the cervical lymphatic glands modified by the scrofulous diathesis are really due to some deposit of tubercle in the first instance. And perhaps the view which has been taken in this article of the pathology of tubercle enables us to understand and reconcile the contradictory statements which appear on this point. For instance, the substance found in the lymphatic glands that one pathologist calls tubercle, another says is only degenerate lymph; while those most conversant with the subject admit that there are certain forms of deposit seen in the lymphatic glands and elsewhere, in which the distinction of degenerate lymph from tubercle is impossible. There is certainly, as Virchow remarks, a close correspondence between the cells of the gray granule and the corpuscles of the lymphatic glands; a correspondence, he adds, which is neither accidental nor unimportant. As there are, in fact, all degrees between the most plastic lymph and the most degenerate tubercle, it is clearly impossible, even pathologically, and much more impracticable surgically, to distinguish by any definition the cases which should be called tuberculous from those which are not. Extreme cases are sufficiently clear; it is concerning the intermediate ones that the doubt occurs; and the difficulty is often evaded by describing them as inflammation of the glands occurring in a scrofulous constitution, and modified accordingly.

It is a characteristic feature of tubercle that it is deposited insidiously. Generally it is not preceded by any symptoms which we are able to recognize. We have no warning of the event; no local disturbance in the first instance; no pain at the commencement, and comparatively little at any time. It is often curious to witness the great and singular disproportion between the pain and the local mischief. The first symptom which attracts attention to the cervical glands is their enlargement. Their position is manifested by their induration and prominence. Before they become apparent to ordinary observation, a careful examination of the region they occupy will often detect them slightly enlarged and indurated as distinct and movable kernels along the borders of the sterno-mastoid muscle. At this time the slight change is perhaps due to increased vascularity, which may be antecedent to, or coincident with, the deposition of tubercle; for they will often at this time, under more favorable circumstances, subside and disappear; a happy event, which is by no means a common one when tubercle is once unequivocally deposited.

When tubercle, then, is once deposited, it may either remain, perhaps for a long time, quiescent, or it may continue simply to increase. The adjacent glands, under these circumstances, partially blend together, and sometimes form very considerable and ugly masses in the neck, looking and feeling like small potatoes beneath the surface. Or, after a while, it may undergo calcareous degeneration, as previously described; the organic matter being absorbed, until by and by nothing

is left but a small cretaceous fragment in the substance of the gland. Or, lastly, as its usual tendency is, sooner or later it may soften, and so give rise to more active symptoms. Even after the mass has softened, it may still be, and often is to some extent, absorbed; but usually the liquefaction is followed by its discharge. The surrounding parts inflame, and pus becomes mixed with the softened tubercle; the integuments over it become thinner, and "point," and at last give way. This process only differs in degree from the course of an ordinary abscess in the vigor of its action and the rate of its progress. It is altogether more indolent. The inflammation is less intense, and its symptoms much milder. The "pointing" is less concentrated. The matter discharged usually consists of curdy flakes in a thin, turbid, yellowish liquid.

Dr. Latham, in his well-known lectures on Clinical Medicine, has graphically described this process of softening and expulsion of tubercle in the cervical glands as an obvious illustration of what so often occurs elsewhere in parts hidden from our view. He divides such cases into two principal classes. In the first there is only a necessary amount of inflammation excited, just sufficient to accomplish the result, and which subsides as soon as that is effected. This, he says, is called the "specific limit" of the disease. "By this is meant the limit proper to its local morbid action, which, for any purpose it has to accomplish, it never need to transgress." In the second case the inflammation may spread beyond its specific limit, and become much more severe and extensive than is needed for the mere elimination of the tuberculous matter. It may extend widely and deeply. This distinction is of great importance, especially with reference to treatment.

It sometimes happens that after the tuberculous matter has been discharged, very intractable ulcers are left behind, and similar ulcers of the integument are often seen, which we reasonably conclude to have resulted from the deposition and discharge of tubercle. They are often preceded by ill-defined deposits in, or indurated patches of, the integuments and subjacent tissue. These, after a while, inflame and soften, and discharge a thin turbid pus. Often the mischief extends more deeply, as in the neighborhood of joints; but the same course is followed: first, the deposit and the induration; then the liquefaction and inflammation; at length the abscess with its serous and curdy pus; and finally, but too often, the indolent and intractable ulcer. These ulcers assume all sorts of shapes, but are almost invariably irregular in outline. The surface is uneven, with large, pale, and flabby granulations; the edges rounded, thickened, and often undermined. There is generally in the less chronic forms some surrounding redness, but it is of a dusky and livid hue. They are usually remarkably passive, torpid, and stationary.

When these abscesses or ulcers heal, generally a very obvious scar results. The cicatrix is dense and thick, and frequently deeply colored, from passive congestion. Often it is considerably depressed; sometimes the surface is raised into ridges. Its continued contraction often causes considerable puckering of the integuments around.

When tubercle is deposited, in addition to the constitutional treatment to be spoken of presently, what can be done locally?

So long as active symptoms are absent, perhaps the less that is done the better. The great object is, to prevent inflammation; and this is best averted by protecting the tumor from all sources of irritation, and keeping the parts in as quiet a condition as is possible. Frequent handling is particularly mischievous. While it remains passive, any kind of interference is more likely to do harm than good, by exciting active symptoms either in the tumor or in the parts around. Of course, if there be any tendency to absorption, if the tumor should at all diminish, the indication for doing nothing is still stronger. If, after the lapse of some considerable time, weeks or months, the tumor should still remain passive and stationary, it may become proper to employ, cautiously, some means with the view of stimulating absorption. Gentle and uniform pressure, if the situation will admit of it, or some mild stimulating application, such as a weak solution or the ointment of iodine, or oil gently rubbed over the surface with or without the addition of camphor or ammonia—these and similar applications sometimes appear to be beneficial; but their effect must be closely watched, and discontinued if any symptom of vascular excitement should present itself.

But supposing, as is sometimes the case, that, in spite of these or even still stronger applications, the tumor remain indolent and stationary, should any other measure be adopted? Should it be removed by operation? Hardly ever. Such a case may occur—cases have occurred in which tuberculous glands have been successfully removed by the knife, but far more frequently the operation has been followed by very uncomfortable results. Enlarged absorbent glands, whether from tubercle or other causes, especially in the neck, are very deceptive. When examined through the integuments, the mass may appear to be well defined, isolated, entirely superficial, and freely

movable upon the subjacent parts; but when exposed in an operation, a small portion of it perhaps is found to creep under the sterno-mastoid muscle, or into some deeper portion of the neck. This leads to, and is connected with, another gland, also enlarged and diseased, but which lay too deep for detection before it was exposed. This, of course, must not be left; but the attempt to remove it discovers that it is in the same way connected with several others affected like itself; and so the surgeon finds himself at the commencement of the chain of glands very appropriately called "concatenatæ," and what is worse, in the midst of structures which prudence declines to dissect. So the operation must be completed with this very unpleasant result—a small part of the disease removed, and the greater portion left behind. The operation can be justified only when the tuberculous gland has remained for a very long time stationary in spite of all local measures and constitutional treatment; when from its size or situation it is either seriously inconvenient, or an unsightly deformity; and when, so far as a careful examination can discover, it is not connected with diseased glands more deeply situated.

When tubercle in a gland or elsewhere begins to soften, the object of the surgeon is to conduct it to its issue with the least possible amount of disturbance to the surrounding parts, to keep the inflammation within its specific limit. Water-dressing with warm fomentations is usually most comfortable. Poultices, generally speaking, do not agree very well; but occasionally a light bread poultice, made according to Abernethy's prescription, proves very grateful. I venture to question the propriety of the recommendation to open these abscesses early. The grounds for this practice do not appear to me to be valid ones. So far as I have been able to observe, when the inflammation is not unduly extensive, after suppuration has occurred, and the central portion of the mass has become soft and fluctuating—and as the integuments over it become thinner, there is generally a sensible diminution of the surrounding disturbance—the area of inflammation contracts. Moreover, in these cases, just at the period when an ordinary abscess would point and discharge its contents, these often recede, not spreading into the parts around, but apparently by absorption. There is less tension of the integuments. They become relaxed, sometimes appearing slightly shrivelled, and the blush of inflammation is less vivid and extended. I believe that these salutary changes are often prevented by too hasty interference. In these cases, as a rule, the symptoms of suppuration are not of that urgent character which renders an early evacuation desirable. The pain is seldom severe. The constitution is not often disturbed. Of course when the inflammation is disproportionably severe and extensive, the question is entirely different; measures more prompt and active then become necessary. Sometimes the abscess will disappear altogether without opening, but an artificial aperture is generally advisable when a natural one appears inevitable. This should be very moderate in size; extending only through that portion of the integument which appears unlikely to survive. The puncture should not be followed by pressure. It can do no good to force out violently that which will flow out naturally. Unnecessary pain is inflicted, and still more important mischief is often effected, by bruising parts which are not able to resist, but very prone to resent, such an injury. The mischievous effects of pressure may not be, and are not always, obvious; but I believe the balance to be, even then, on the side of evil.

[Aspiration now offers the most approved means of treating scrofulous abscesses. It may be repeated from time to time; and, in some instances, the abscesses will gradually contract and finally disappear altogether. The method of dealing with psoas abscess and other lesions of similar nature belongs to the sections treating of special diseases rather than to the present general consideration of scrofula. Under special heads the reader should look then for special lines of action, such as hyperdistension with carbolized water after aspiration, etc.]

These abscesses too often degenerate into those troublesome and obstinate ulcers previously described. The best local applications are those which are gently stimulant, such as Peruvian balsam, the tincture of benzoin, the red oxide of mercury, a weak solution of nitrate of silver, etc. Sometimes the surface may be touched with nitrate of silver or sulphate of copper with advantage; and when the edges are spongy and livid, it may be proper to destroy them with caustic, or to remove them with the knife.

The question is often raised, whether, supposing we were able to do so, it is desirable, in certain cases, to heal these ulcers. It is believed that they may act as natural outlets for an exudation which might otherwise be deposited in more important parts. The fact is, until the state of the constitution is improved and the tendency to the deposit counteracted, there is not much chance of healing them; and, when the general health is restored, they will spontaneously close without risk.

That they heal, may be generally accepted as a proof that the source of danger is removed.

This question becomes more doubtful when raised with respect to the performance of a capital operation, such, for instance, as the removal of a portion of a limb for what is usually termed scrofulous disease. In such a case the decision must depend on the state of the constitution ; the condition of the more important organs, as the lungs ; and the effect which the disease, whose removal is contemplated, has upon the system. Have all other means failed ? Is the patient able to bear the operation ; that is, is there power sufficient to accomplish the process of repair ? If there be extensive or active disease in the lungs, the operation can only hasten the catastrophe. Can the disease in the extremity be so conclusively connected with the constitutional symptoms, the hectic fever, as cause and effect, as to render it fairly probable that they will subside when that is removed ? This question is one ot the most difficult that the surgeon is ever called upon to answer. A sound decision in any case can be found only upon careful and continued observation.[1]

[The belief expressed by Mr. Holmes[2] and others that tuberculosis is often the result and not the cause of a chronic suppurative lesion, points to the necessity of removal of the affected parts at a comparatively early period ; while deprecating hasty operations in such cases, but thinking with Dr. Sayre, of New York, that many so-called scrofulous diseases are traumatic in etiology, and the cause rather than the result of the constitutional perturbation, numerous practical surgeons now advocate operations, where in former years the local disease would have been left untouched, and constitutional measures relied upon for relief. Mr. Bryant of Guy's Hospital, in discussing this subject[3] concurs in the above opinion, and thinks that local joint disease has often been regarded as an evidence of a "scrofulous" diathesis. He has seen progressive lung disease, associated with joint disease, subside after amputation, thus showing the deleterious effects of local suppurative action of long duration. The amyloid changes taking place in the viscera secondarily to prolonged bone disease are familiar to all medical men.

Niemeyer suggested some years ago that the danger of pulmonary tubercle resulting from cheesy inflammatory deposits, might in future be an indication for the extirpation of lymphatic tumors and the performance of major operations.

The prophecy made on the basis of his pathological investigations has already begun to be fulfilled.

Undoubtedly constitutional measures must be combined with local treatment in the management of scrofulosis, but the bearing of cheesy deposits in any region of the body, upon the production of gray tubercles, renders the prompt removal of such deposits a matter of moment. Whether the constitutional symptoms, however, are believed to be secondary or primary, they require therapeutic relief, since local and constitutional symptoms have a reactionary influence upon each other.]

But in the treatment of deposits of tubercle, local means are worthless in comparison with constitutional measures. It can avail but little to encounter the effect alone, while the cause is still in operation. The grand indication is to arrest, if possible, the tendency to the formation of tubercle. The treatment of the deposit is comparatively of little moment.

[It will here be apparent that our author inclines to hold to the diathetic nature of the lesions calling for treatment ; but it must be remembered that at this stage of his essay, he is not discussing the original source of tuberculous infection, but the lesions occurring and demanding treatment after the diathesis or constitutional condition has been developed, whether by heredity or by self-infection.]

Amongst drugs, those most esteemed in the treatment of this disease are, iodine and iron, bark [quinine and its other alkaloids], the alkalies and mineral acids, and, above all, cod-liver oil.

Before a course of any medicine is commenced, the condition of the digestive apparatus should be carefully scrutinized, and any disorder of it should be, so far as it is practicable, rectified. While those symptoms previously enumerated exist, matters are only made worse by the exhibition of tonics. A disordered state of the digestive organs is most commonly seen in children, and is best treated by strict attention to the diet, and the regular use of some mild aperient for a few days or longer. A few grains of rhubarb and soda for some nights in succession, occasionally combined with a little gray powder, and then followed by a dose of castor oil the next morning, in order to clear out the canal, usually succeed very well. But it is needless to enter into detail. The principle of treatment is the point to be insisted on. Concerning the

[1] See elsewhere for the special description of tubercle in the bones, and other local deposits.

[2] Surgery, Its Principles and Practice. London Ed., 1875, p. 344.

[3] Practice of Surgery. 3d Amer. Ed., by Roberts, p. 20.

method of carrying it out, almost everyone has some especial fancy of his own. Assuming, then, this difficulty to be absent or to be overcome, the way is clear for the employment of tonics.

The preparations of iodine are most likely to prove serviceable in the absence of all fever and vascular excitement. If these are present, they often only increase the mischief. They may usually be prescribed with advantage in simple but concentrated decoctions of sarsaparilla. [Iodide of potassium and iodoform are often available. The odor of the latter is well concealed by oil of aniseed.]

Iron, as might be expected, is sometimes eminently beneficial. Its use is especially indicated when the symptoms of anæmia predominate; when the blood seems poor in red cells; still more if this be combined, as it commonly is, with a feeble circulation and a general want of tone. Among the milder preparations are the ammonio-tartrate and citrate, and the potassio-tartrate. The last is especially useful for children, and has the additional advantage of being compatible with the alkalies. The vinum ferri, too, is a mild and simple preparation, and very often a most valuable one. But the sulphate of iron, when it can be borne, is sometimes much more efficacious, and the tincture of the perchloride is perhaps the most powerful of all. But iron will not suit the system in all cases of mere debility. When the lips and conjunctivæ are florid it is least likely to agree.

Iron and iodine may be often very profitably prescribed in combination. The syrup of the iodide of iron is a very convenient form.

Bark, and its preparations generally, are particularly useful, during the period of suppuration, in supporting the system and averting hectic fever. It is curious to observe what effect it sometimes exerts upon this process. It tends to bring matters to a crisis. Doubtful symptoms of activity in and around the deposits will often subside; and a slow, languid, imperfect suppuration is often pushed forward into a more healthy action. When the flesh is flabby, when there is great debility, when the appetite is bad and the excretions tolerably healthy, then bark is indicated. Iron and quinine combined are often eminently useful.

In such a case the mineral acids also are generally given with advantage. They are deemed especially useful in checking the profuse perspiration of hectic fever.

The alkalies and their carbonates are often very useful in the treatment of strumous dyspepsia. They are more particularly indicated when the urine is highly acid, and contains an excess of the lithates, or still more, any free lithic acid. For children, lime-water, either in milk or sarsaparilla, is often serviceable, or the carbonate of magnesia held in solution by excess of carbonic acid. [Chlorate of potassium is lauded by some writers.]

When there is much local disturbance about a tuberculous deposit; when the inflammation appears to be independent of any change in the mass itself; and more especially if this be combined with any gastric disturbance, the operation of an emetic will often be followed by signal improvement.

Aperients and purgatives are perhaps too often employed in mere routine. During a course of tonic medicine they are generally required from time to time, and always when the state of the tongue and the excretions indicate a loaded condition of the intestinal canal, or the presence of morbid matter, such as imperfectly digested food, or depraved secretions.

[Mercurials may be employed with advantage at times. Small doses long continued, in order to get what has been called the tonic effect, should be the rule.]

But of all medicinal remedies for scrofula none at present enjoys so high and well-founded a reputation as cod-liver oil. The fixed oils, as a class, are often beneficial; and it is curious to note, in connection with this fact, when considered in its relation to nutrition, that some have observed very often in cases of scrofula a peculiar dislike to fat; but for its efficacy cod-liver oil surpasses every other. Some have sought for the cause of this superiority in the iodine, bromine, phosphorus, and other of its constituents. But the proportion in which these exist is too minute to render it probable that they have any considerable share in such important results; and, moreover, these elements have been used in various other combinations without benefit at all comparable with that which is obtained from the oil. Perhaps its excellence may be more closely connected with its disposition to form an emulsion more readily than other oils, for it is peculiar in saponifying with the carbonates of the alkalies. This may possibly in some measure explain its more ready absorption from the intestinal canal. It has been suggested also that it is more easily digested than other oils, because it contains, to some extent, the principles of the bile.

The beneficial effects of the oil are very general throughout the body. But the most remarkable, although probably by no means the most important, is the increased accumulation of fat. When it first came into general use, people were surprised at the rapidity and extent of its

action in this respect. Great difference of opinion still prevails as to the particular kind of cases in which it is most serviceable. It is assuredly more or less so in the vast majority.

But that the best effects may be obtained from its use, it must be taken for a very long time. Want of perseverance here is attended with its usual result—disappointment. It is not a question of days only, but often of months, or even years. It should therefore be regarded as an article of diet rather than as a medicine, and usually, after a while, the dislike to it ceases. A tablespoonful may be considered a full dose for an adult; but this quantity should be gradually arrived at, commencing with a teaspoonful. It may be taken twice or thrice daily, and immediately after a meal; for at that time it is least likely to create nausea, and, moreover, it does not then interfere with the appetite. It may be taken upon a small quantity of some other fluid, such as a little wine or a bitter infusion. When the stomach is weak and there is a tendency to nausea, a solution containing the fortieth or thirtieth of a grain of strychnia, acidulated with nitric acid, often proves a most useful vehicle. This I first learned from Dr. Williams. Some people, and especially children, can take the oil alone without any discomfort. Again, some persons can take it for any length of time with impunity; but in the majority, after a while, it is apt to create nausea, and produce other symptoms called bilious. I think the best way of avoiding this is to suspend its administration for a day or two, now and then, and if necessary, at that time to give an aperient. Of course it is much less likely to disagree when the digestion is good, and it can be taken much more comfortably by those who are able at the same time to use exercise. As might be expected from its composition, it can, as a rule, be taken in larger quantities, and for a longer period, in cold than in warm weather.

Probably the lightest and clearest oil is the best. It has never been shown that the darker oils possess any additional advantage, and they are much less likely to be well borne. In cold weather the oil should be slightly warmed before it is taken, for it is thus rendered less tenacious, and is more readily swallowed. These details should not be despised. In almost all cases it is of the utmost importance that the oil should be taken, and by due attention to such details as those just alluded to, this may generally be accomplished.

But, after all, medicines, even cod-liver oil, should be only accessory to hygienics. Sometimes, perhaps often, in the earnest application of some particular remedy in the treatment of disease, we are apt to neglect the adoption of those more general means by which diseases are averted and the health is preserved.

With regard to scrofula, whether tubercle be already formed or not, all the causes previously mentioned should, so far as they can, be avoided. All causes of debility should be carefully shunned, and the system should be raised as nearly as possible to the level of perfect health.

The food should be nutritious and sufficiently abundant, and should contain a fair amount of proteine principles. Stimulants, if needful, should be taken in moderation, never in excess. A mother with scrofula should not suckle her children, for this is prejudicial both to her and them; but a healthy wet-nurse should be obtained; and Sir James Clark recommends that the child should not be weaned until the period of "teething" has passed. The due warmth of the body, not neglecting the extremities, should be secured by adequate clothing, and flannel should always be worn next the skin. Constant residence in pure and dry air, and regular exercise proportioned to the strength should be recommended. If proper exercise cannot be taken daily, friction of the surface with a flesh-brush may be substituted. Tepid or cold bathing is useful, especially in salt water, if it can be borne, and is followed by perfect reaction. The mind should be cheerfully occupied, but not unduly tasked. This last point is especially important in regard to children. Too often, in the natural anxiety to educate, the state of the health is overlooked or forgotten. Unfortunately, the scrofulous diathesis is frequently accompanied by unusual activity of mind, which is apt to be encouraged, but needs to be restrained.

It has been already stated that the climate of Great Britain is not the most congenial for those who possess the scrofulous diathesis. Yet there are some situations free from the most important objections; where the atmospheric changes are less frequent and sudden, and the winter comparatively mild. When the diathesis is more strongly marked, it often becomes necessary, in order to avert its further development, to seek abroad a milder and more equable climate.

But it is surely a mistake to suppose that a warm climate is the one best adapted to all cases of scrofula. It is so doubtless in the great majority in which the disease is far advanced; but in many cases, at an earlier stage, its further development is more satisfactorily arrested and the general health improved by a more bracing air. Children with tuberculous glands,

but whose health appears otherwise tolerably good, would perhaps profit less by transportation to Madeira or Egypt than by residence on the south or west coast of England. Delicacy of constitution is sometimes increased and mischief encouraged by dread of exposure. [Minnesota was formerly greatly resorted to by consumptives, but of late Florida and Colorado have attained considerable reputation as health resorts. The Hot Springs of Arkansas are held in high repute for the treatment of syphilitic and scrofulous affections.[1]]

Of course, on all these subjects relating to hygienics, there are many matters, other than those with which we are concerned, to be taken into consideration. All depends upon the person's position in life and the circumstances by which he is surrounded. It is often only a choice of difficulties involving more than one vital question.

SYPHILIS.

"La syphilis devrait servir de clef à toute la pathologie."—Andral.

By Henry Lee, Esq.

Revised by James Nevins Hyde, M.D.

I. Introduction.

When syphilitic matter is applied to the surface of the human body, no appreciable effect in general results; but when the poison comes in contact with the thin skin in those situations where it joins the mucous membrane, or when applied to the mucous membrane itself, or to the skin in places where the epithelium has been removed, then inoculation may take place. As observed in practice, the results of inoculation afford considerable variety; when artificially performed, they are much more uniform.

Four distinct and well-marked morbid processes may follow syphilitic inoculation:—

1st. The inoculated part may become affected with the "adhesive form of inflammation," in which lymph is poured out either in the substance or on the surface of the part.

2d. The absorbents may assume an active share in the morbid process, taking up some of the infected parts, and with them portions of the syphilitic poison. This process will, in the following pages, be called "lymphatic absorption."

3d. The inoculated part may, within a few days of the application of the poison, be affected with suppurative inflammation; and

4th. The morbid action may terminate in mortification. Of this there are two practical subdivisions:—

(*a*) Death of the whole infected part, which is then thrown off as a slough; and

(*b*) Dissolution and death of a part only of the contaminated structure, leaving a part still infected.

These four kinds of morbid processes, essentially distinct when once developed, usually maintain their original character until the termination of the disease. Thus the specific adhesive inflammation may be recognized by its characteristic induration often long after the sore (which usually accompanies it) has permanently healed. But it will, nevertheless, occasionally happen that the action will become changed, and this altered condition (if careful attention be not paid to it) will lead to an error in the diagnosis. A sore affected with adhesive inflammation, upon the application of some fresh irritant, may become a suppurating sore. The superinduced action may perhaps modify, but will not prevent, the specific results of the original disease; or again, a sore that has presented for a time the characters of the suppurative inflammation may alter its appearance and assume those of the adhesive form. In such a case, the first disease will not prevent the constitutional effects of the second.

Both these forms of action will constantly be accompanied by "lymphatic absorption;" and the disease in the lymphatic glands will be of the same nature as that whence the absorbed product

[1] See "Rocky Mountain Health Resorts," by Charles Denison, Boston, 1881; and "Report of Committee on Sanitaria and on Mineral Springs," in Trans. Amer. Med. Assoc., 1880, p. 537.

was derived. It will also sometimes happen that the specific adhesive inflammation may terminate in mortification, or that a part superficially mortified may become affected with specific adhesive inflammation. In either case, the mortification may be superficial, or extend to the whole of the infected tissues; but if the specific adhesive inflammation has once taken place, its effects upon the constitution will subsequently appear.

The above four kinds of diseased action, resulting directly from the application of the syphilitic poison to the surface of the body, may be clearly traced both after artificial inoculation and by attentively observing the natural course of the disease in different instances. It must always be borne in mind that the character of a sore at one time is no certain indication of what it may previously have been, or of what it may ultimately become. In the mode in which the disease is usually communicated, a part may be subjected to influences which would have a tendency to produce more than one morbid action. Such influences may be applied either at the same or at different times. When applied at the same time, a twofold inoculation may occur on the same spot; and if the consequent respective actions require different times for their development, one disease may first run its course, and be subsequently followed by the other, which will then go through its different stages, modified perhaps, but not altered, in its essential characters, by the first.

The number of poisons which may produce morbid actions in a part scarcely admits of demonstration. Two different poisons may sometimes produce the same action. Thus, the secretion produced by the puncture of a foul lancet, and that arising from an injury to a portion of cancellous structure of bone, may both give rise to erysipelas; or, on the other hand, the same poison may, under different circumstances, give rise to more than one kind of morbid action.

It does not, then, follow that because we can distinctly trace so many morbid processes, there are the like number of morbid poisons. The diseased actions we can trace with great precision, and can predict the circumstances under which they will occur, and define distinctly the laws by which they are regulated and controlled. It is, therefore, more in accordance with strict inductive science, simply to describe the different *modes of action* which occur after impure contact, than to ascribe each different action to a different poison.

Hunter believed that gonorrhœa was always produced from the same virus as syphilis, and nearly all the practitioners who followed him were of the same opinion. Swediaur, however, remarks that the happiness and tranquillity of many families, not less than the fatal effects arising from the improper treatment of this disease, seem to demand the most careful researches upon the subject. He had convinced himself, from well-authenticated experiments, and numerous cases attended with the greatest care, that those who maintained that gonorrhœa and syphilis were always the effect of the same poison, and those who held an opposite opinion, were both wrong in generalizing too much, and in speaking so positively and so lightly on a point of so much importance to the physician and the patient. He had, as he believed, proved to demonstration that blenorrhagia of the genitals of the two sexes owed its origin sometimes to the venereal or syphilitic virus properly so called, and sometimes to some other acrimony applied to the urethra or the vagina. Several cases are related which go to prove that a discharge may be syphilitic or produced by the syphilitic virus; and, on the other hand, cases are given to show that blenorrhagia is generally very different in its origin and nature from the disease produced by the syphilitic virus. It will easily be conceived, he remarks, of what importance this distinction is in practice, when, on the one hand, we see practitioners treating all gonorrhœas as venereal (syphilitic) with mercurials; and, on the other, by an ill-founded theory suffering the syphilitic virus to be communicated, and the disorder propagated through whole families, without giving themselves any trouble as to the unfortunate results. This, in a few words, gives perhaps the best account of the theories of the nature and treatment of syphilis extant in 1821.

In 1838, Ricord's *Traité pratique sur les Maladies Vénériennes* appeared, and this must always remain a most important epoch in the history of syphilis. Ricord professed to demonstrate the truth of his views by experiment, and offered his experimental illustrations to all who might wish to witness them. With triumphant success, and to the satisfaction of his admiring pupils, Ricord demonstrated daily the great fact, that when pus was taken from the urethra in a case of gonorrhœa, and inoculated upon the patient, no result followed; whereas when pus was taken from a suppurating sore, and inoculated with the point of a lancet, a suppurating chancre was always produced. A great triumph had here been achieved. Science had vindicated her right, not only to distinguish between different morbid processes, originating apparently in the same way, but also to reproduce some of these actions, and experimentally to trace them through their various stages. With the

light thus derived from experiment, the following conclusions were arrived at by M. Ricord :—

I. A chancre is known for certain, neither because it has appeared after a suspicious contact, nor on account of its situation, nor because it has an indurated base, nor on account of its color, its shape, the character of its edges, nor by the red areola by which it is surrounded, but by its being inoculable so as to reproduce exactly the same disease again upon the same patient an indefinite number of times. All the other conditions may vary ; this alone always remains the same, and affords the same experimental results.

II. The pus of a chancre can alone produce a chancre.

III. The best way to produce a chancre is to inoculate some of the secretion from its surface upon another part of the same patient's body.

IV. Beyond the contact of the pus introduced beneath the cuticle, no other action is necessary to produce a well-developed chancre.

V. The inoculation never fails when the pus is taken under the necessary circumstances, and is properly applied.

VI. The pus taken from an inoculated pustule will reproduce a chancre of the same kind originating in the same way, and thus the propagation may extend from pustule to pustule.

VII. When several inoculations are made from the same suppurating chancre, each one gives rise to a separate pustule, which subsequently becomes a chancre. If three punctures are made, we do not see one succeed and another fail. The number accurately corresponds with, and is never more nor less than, the number of the inoculations properly made.

VIII. The pustule, and the chancre which succeeds it, are always developed upon the precise spot where the inoculation is made, and never upon any other part.

IX. Whatever different forms the suppurating chancre may ultimately assume, its course, in its origin, is always the same. The appearance of the pustule is absent only when the part has been excoriated ; and it is preceded by phlegmonous inflammation only when the poisonous matter has been introduced into the subcutaneous areolar tissue, or has found its way into the lymphatic vessels.

X. There is no period of "incubation," in the sense in which this word is generally understood. There is for the suppurating sore but one process of development, from the contact of the contagious pus to the formation of an ulceration.

XI. The chancre is in its origin a local disease.

XII. The origin of the affection must date from the period of contact, and not from the time that the patient perceived the disease.

Such are the results of M. Ricord's investigations, published in 1838, and they furnish a very faithful abstract of the evidence which he had obtained by his experimental mode of investigation. Every conclusion is based upon direct observation ; and if there had been one form of syphilitic disease, and one only, M. Ricord's conclusions must have stood the test of subsequent experience. But it has now been proved by numberless observations, and by more direct experiments than may, perhaps, be justified, that the syphilitic action which arises after contagion is not always the same. The specific pustule, it is true, when inoculated, will as a rule produce the specific pustule ; but there is another form of disease, of far more importance to the patient, which does not begin with a pustule at all ; which cannot be re-inoculated upon the patient who has it ; which often has a prolonged period of incubation ; which cannot be destroyed by caustic, and which is followed very certainly by secondary symptoms.

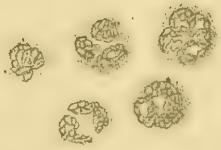
The two actions now mentioned have unfortunately, up to a recent period, been confounded together. It will now be my endeavor to distinguish accurately the symptoms which belong to these two essentially different morbid processes, and to describe each as a separate affection.

M. Ricord's description, then, applies in general very accurately to the suppurating form of the disease ; but it does not apply to that which, in its origin, does not begin with a pustule, but which begins with some adhesive form of inflammation —such as a papule, a tubercle, or an abrasion with a thickened base.

In the next section we shall consider the suppurating syphilitic sore, and in the sections following, the disease which gives rise to the hard chancre, and its consequent constitutional or secondary symptoms. The results of *twofold* inoculation as they present themselves in nature, under different forms, will subsequently be described, together with the various complications which may thence arise.

II. Suppurating Syphilitic Sore.

The *primary suppurating syphilitic sore* is a local disease, and is not liable, so far as I am aware from personal observation, to infect a patient's constitution so as to produce secondary symptoms. It commences as a pustule, and runs a definite course. When artificially inoculated, the inoculated point becomes red within the first twenty-four hours. From the second



to the third day it becomes slightly raised, and is surrounded by a red areola. Between the third and the fourth day it contains a fluid more or less turbid. From the fourth to the fifth day the pustule becomes fully formed, and from this time to the termination of the disease the secretion consists of well-formed pus. Sooner or later, the cuticle covering the pustule is detached, and in some instances it may be removed at the time of the inoculation, whether artificial or natural. This alters the appearance of the affection, but in no-wise interferes with its essential characters. As soon as suppuration commences, there is a loss of substance in the part, and an ulcer forms, which has peculiar characters. When not interfered with by any accidental causes, it increases equally in every direction, so as to form a more or less perfect circle. The edges of the ulcer are cleanly cut, and present a sharp outline. (See Plate I. fig. 1.) The appearance presented is often that of a piece of skin having been removed by a punch. The edges of the ulcer are frequently slightly undermined and everted. The surface of the ulcer is irregular, sometimes presenting granulations, at other times the appearance of having been worm-eaten. Often the bottom of the ulcer is covered by an adherent, grayish, tough matter, which probably is a part of the natural texture which has undergone a kind of molecular necrosis, and is in process of being separated from the subjacent living parts.

Suppuration in itself does not necessarily involve a loss of substance, but these suppurating sores nevertheless generally leave permanent and depressed scars. This evidence of loss of substance is probably in exact proportion to the degree in which the form of molecular necrosis above alluded to has been present in any individual case. The suppurating syphilitic sore gradually increases during a certain period, then remains stationary, and finally heals. The latter process is indicated by the base of the sore becoming clean and covered by red granulations, by the red areola which surrounded it becoming fainter, and by the edges of the wound gradually losing their prominence.

Such is a description of the typical form of a suppurating chancre; but this may be modified by various accidental causes, of which the following are some of the most important:—

1. If the specific pustule be destroyed by the application of caustic within the first five days of its existence, a simple ulcer alone will remain. This will then have none of the characters of the specific disease.

2. When a chancre during its progress meets with tissues of different natures, or when folds of the same texture are involved, its shape and appearance may be thereby modified.

3. Should the specific inflammation extend to the areolar tissue, a certain amount of inflammatory exudation will there take place. This will produce an induration at the base of the chancre, and will sometimes very much resemble the induration which ordinarily accompanies the infecting chancre. The latter will be particularly described in the next section. The induration that surrounds the suppurating form of the disease gradually fades towards the circumference to the consistency of the surrounding parts. When this inflammatory exudation, however, in its progress meets with a different kind of tissue, it may terminate quite abruptly, and then it may be impossible to distinguish, by the touch alone, this kind of induration from that of a chancre which infects a patient's constitution. The character of the secretion of the sore, or its inoculability on the same patient, or the history of the case, must then be relied upon to distinguish the disease.

Case.—A patient, who considered himself well informed upon the subject of the characters of an infecting sore, presented himself in March, 1859. He had a sore on the right side of the frænum, which spread ultimately for about three-quarters of an inch along the urethra. As the sore extended, it became surrounded by considerable induration, and this, as it approached the urethra, terminated quite abruptly. It was then impossible to distinguish this induration from that which accompanies an indurated infecting sore, and the patient believed that his affection presented all the characters of a true Hunterian chancre. The history of the case and the character of the secretion furnished, however, different testimony; and the patient was prevailed upon, not without very considerable difficulty, to be treated for a local disease. I ventured to assure him that his constitution would not be affected; and I had the satisfaction of seeing him on November 5, 1860, and again on February 21, 1862, without his having been subjected to any constitutional treatment, and without his having had any constitutional symptoms.

4. The most remarkable accidental circumstance which modifies the course of a suppurating chancre is the absorption by the lymphatic vessels of a portion of the affected tissues, or of the secretion which they have produced.

Lymphatic absorption of the product of a suppurating syphilitic sore affords the same evidence of the nature of that sore as does artificial inoculation. The secretion transferred to another part is followed by the same effect, whether artificially conveyed by the point of a lancet, or by the natural

process of lymphatic absorption. In either case, where the seed takes root, there will it germinate and produce its natural consequence. The morbid process which ensues terminates surely, and without any period of incubation (in the ordinary acceptation of the term), in the formation of a small quantity of matter which always has peculiar properties. This matter is *pus*, and pus which has the property of always reproducing its specific action when again applied to another part of the same body, or when inoculated upon another person. This pus is therefore called *specific*. To the naked eye and to the microscope it presents all the characters of ordinary pus; but it has, in addition, its specific qualities, which are known only by their effects. It presents, as seen by the microscope and even by the naked eye, characters which distinguish it from the secretion of the indurated sore, or of the infecting form of syphilis. It consists of well-formed pus; and each globule is of nearly the same size, and distinct from the rest. If, in any doubtful case, some of the secretion from a sore be mixed with a little dilute acetic acid, and placed under the microscope, the distinctive characters of the pus-nuclei will be seen, as represented in Plate I. fig. 2. The appearances produced are quite distinct from those which are afforded by the secretion from an infecting sore treated in the same manner, as will be more fully shown in the next section.

When this specific pus has produced its natural effect either in a lymphatic vessel or in a lymphatic gland, the fresh portion of pus thus generated produces a fresh specific irritation, and this irritation produces an abscess which, breaking externally, discharges its contents. In such a case the matter in the interior of the gland, or lymphatic vessel, constantly retains its specific characters; but that which during the process of suppuration is formed outside the vessel or gland is ordinary non-specific pus. As the disease advances, these two secretions may be mixed together, and then the whole acquires the characters of the specific fluid, and the surface of the whole sore will become inoculated.

Lymphatic absorption from a suppurating syphilitic sore then necessarily produces a suppurating bubo. Any attempt to prevent such an affection from suppurating is entirely futile. The disease within the lymphatic system is the same, and runs a similar course, as that upon the surface of the body.

The disease now described is not beneficially influenced by mercurial treatment; and inasmuch as it has no tendency when left to itself to infect a patient's constitution, any mercurial treatment in order to prevent such an infection is entirely superfluous. The suppurating syphilitic sore will sometimes be tedious in healing, and a variety of applications may be tried sometimes without producing any apparent effect upon the course of the disease. In a case lately under my own care at St. George's Hospital, a sore of this nature lasted four months, apparently little influenced by treatment; but the patient at the end of that time made a very good recovery, and now remains well, without having taken any mercury.

[American writers are generally agreed in applying the term "chancroid," first used by Clerc, to the lesion described by Mr. Lee as the "suppurating syphilitic chancre." The complete exclusion of every feature of syphilis, throughout the career of each of its several classical forms, may be regarded as one of the great achievements of modern research. Without, however, discussing here the long-vexed question respecting the unicity or duality of the chancrous virus, the mere statement of which involves a misuse of terms, it is sufficient to note that the author practically recognizes the distinction upon which it is now intended to lay emphasis. Consistency requires that the word "syphilitic" should not be applied to that venereal ulcer which, in uncomplicated cases, is never followed by the disease syphilis.

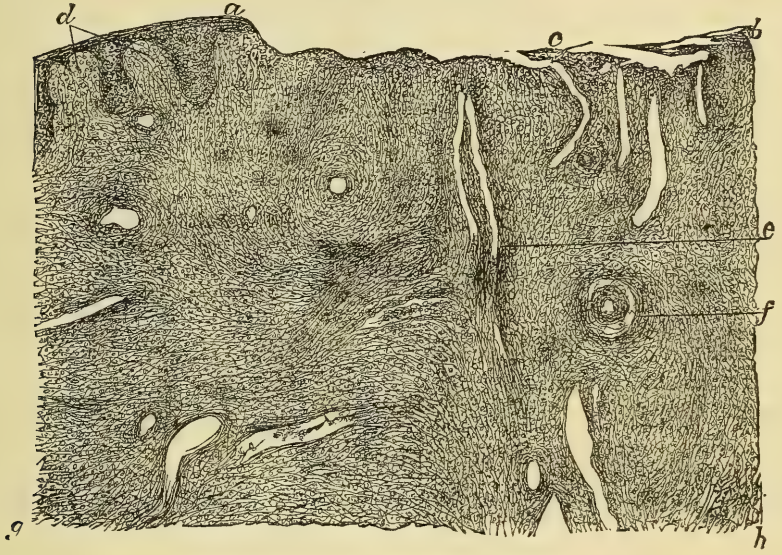
The progressive relative infrequency of the chancroid lesion, noted in France and elsewhere for several years past, is now apparently succeeded by a term of its more frequent occurrence. The recent great wars in Europe have probably had an effect in the production of this result by removing large bodies of young men from their homes to the centres of population and commerce.

Beginning commonly enough as a pustule in the manner described above, the chancroid is not rarely encountered as a suppurating abrasion from its earliest phase. This is usually the result of accidental inoculation of some precedent lesion with the virus of the propagating sore, as, for example, an herpetic or balanitic abrasion; or the open mouth of a follicle may have been directly infected. The history of these varieties does not differ subsequently from that described by the author. In either form, it should be remembered that the sore is frequently multiple, either from the first, or as the result of successive accidental auto-inoculation; now limited to the corona glandis, again spreading over scrotum, labia, and perineum.

Lasting for six or eight weeks only, as described in the text, indolent and serpiginous chancroids, originating in primary ulcers or sequelæ of suppurating

buboes, may last for years. In these cases, the lesion, located near the anal or the urethral orifice, may have been long exposed to irritating physiological or pathological secretions, or situated elsewhere, may have assumed, in consequence of neglect or a cachectic condition of the patient, the unhealthy aspect which has led some observers to the conclusion that these intractable sores constituted a variety of lupus. Jullien[1] represents such an ulcer occupying nearly two-thirds of the abdominal surface. We have treated a similar case where three-fourths of the integument of the right thigh was involved after the lapse of seven years.

Fig. 20.



Section of a chancroid, after Kaposi. (Bumstead.)

Kaposi,[1] examining the chancroid microscopically, describes its floor as composed of a thick cell-infiltration, extending beyond the borders of the ulcer into the loose-meshed neighboring tissue. The exposed surface is the cell-infiltrated corium, whose papillæ are no longer visible though the latter in the swollen margin, are thickened, and stuffed with cells. These cells are large and small, nucleated and irregular in outline, dispersed through connective-tissue fibres of faint contour. There is nothing in all this save the phases of destructive inflammation, which may be studied microscopically in other ulcers.]

The suppurating syphilitic sore has been often repeatedly inoculated for the supposed purpose of producing what has been termed *syphilization*. But inasmuch as the disease, however often repeated, remains a local one still, no constitutional or permanent effect can be produced in this way ; still less can any condition of the system be produced which would render it insusceptible to the infecting form of the disease. It must, however, be admitted that when a patient has already constitutional syphilis, the symptoms which have developed themselves will often disappear under this so-called syphilization. It is principally efficacious in diseases of the skin, and these are probably removed, under the circumstances, in consequence of a kind of counter-irritation produced by the repeated inoculation of the syphilitic matter, and suppuration of the inoculated points.

One very important and interesting fact will require especial notice with regard to the so-called syphilization—viz., that after repeated inoculations have been made on a part, that part becomes less and less susceptible to the influence of the poison, and a time arrives at which the inoculations will cease to secrete pus, and then they will no longer be inoculable. If fresh matter, however, be used, the inoculations will again succeed ; but these will gradually lose their effect, as at first. This process may be repeated until a part is no longer susceptible to any inoculation from the secretion of a suppurating syphilitic sore. But then a fresh part may be inoculated, and the same process repeated. Under this mode of

[1] Syph. der Haut u. d. angrenz. Schleimhäute. Wien, 1873, li. s. 42.

[1] Traité prat. des Malad. Vénériennes. Paris, 1879, p. 443.

treatment it is said that a time ultimately arrives at which no further inoculation can be effected from a suppurating sore upon any part of the body. Even then, however, after the lapse of a certain interval, the suppurating syphilitic sore may again be communicated, but always without imparting any constitutional or syphilitic taint to the patient. This subject will be considered more at length in a future section.

III. Syphilitic Infection.

Syphilitic infection of a patient's system, as far as it can be traced by local symptoms, commences as a crack, an abrasion, or a pimple. These affections, in the *origin*, are often extremely difficult to recognize. They frequently do not present any characters by which they can be distinguished from similar results arising from a variety of accidental causes, and they may be masked by the coexistence of other local venereal complaints.

Syphilitic infection at its first appearance generally attracts but little attention. It is attended with no inconvenience, and the patient is willing to believe that it is "nothing"—an opinion which has been but too often endorsed by the surgeon. As the disease declares itself, it assumes one of three forms, which are all modifications of the adhesive kind of action :

I. The cuticle may appear as if peeled off from the upper part of the glans penis, or a circumscribed patch may remain for days together, presenting a livid or purple color. (See Plate II. fig. 3.) The structures below are not infiltrated, and therefore there is no specific induration. The secretion, consisting of epithelial scales and lymph-globules, of various sizes, and more or less perfectly formed, is thrown off from the surface. In women there is probably a corresponding affection of some parts of the mucous membrane, not accompanied by induration ; but on account of the difficulties attending the investigation of these complaints in their origin in females, such a condition has not hitherto been described.

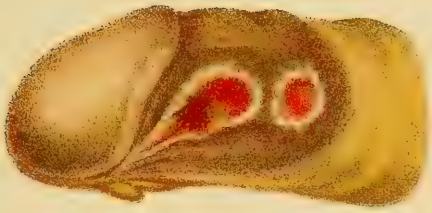
II. An indurated tubercle, without ulceration, may form in the skin or under the mucous membrane, and will then present all the characters of the specific induration without any loss of substance. (See Plate II. fig. 3.)

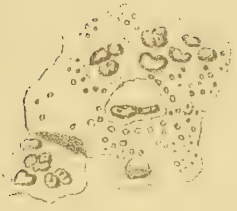
III. The most ordinary form of syphilitic infection is that which has been called the indurated or Hunterian chancre. In this a deposit of lymph occurs in the areolar texture of the skin or of the mucous membrane, and is succeeded by a process of molecular necrosis, by means of which the newly deposited matter is in part thrown off, and an ulcer is formed ; but, inasmuch as it is the newly-deposited material which alone perishes, no depressed scar or permanent loss of the natural tissue occurs. The secretion from an infecting chancre, when the disease is not accompanied with irritation from any accidental cause, is not pus ; it consists of epithelial *débris*, of globules of lymph more or less perfectly formed, or of these same products undergoing disintegration, and of serum more or less turbid. These different products may often be found matted together, mixed occasionally with a few pus-cells. During the time that the adhesive matter is being thrown off from the surface, or whenever a part has been irritated by an adherent scab, or by the application of lotions, some suppuration may take place ; but as soon as the accidental cause of irritation has been removed, the natural non-puriform secretion alone remains. If the secretion from an uncomplicated infecting sore be placed upon a piece of glass, and a drop of dilute acetic acid be added, the microscopic appearances will be found to be very different from those which were described in the last section as characteristic of the secretion from a naturally suppurating sore. The accompanying drawing (Plate II. fig. 4) represents the appearances of some of the secretion from an ordinary infecting sore, examined in the manner above described. In this case the sore, which was in a state of progress, had been dressed with water dressing, in order to prevent any accidental cause of irritation, for two or three days previous to the examination.

In debilitated and unhealthy constitutions, infecting sores will suppurate as any non-specific lesion would do, and in such cases it is sometimes very difficult to distinguish the secretion produced by the local disease from that which depends upon constitutional peculiarity.

The three forms of infection now described are all modifications of the adhesive form of inflammation ; and there is much reason to believe that the first two have not been recognized by a large majority of the writers on syphilis, and that hence a number of cases have been erroneously recorded, in which constitutional syphilis was supposed to have been acquired, without any primary affection.

The induration which accompanies the second and third form of the specific adhesive inflammation is peculiar, and, when well marked, it furnishes a diagnostic test of the nature of the complaint. It surrounds the edges and base of the chancre in every direction to nearly an equal extent. It terminates quite abruptly in the surrounding tissue ; so that it not unfrequently affords the sensation as if a foreign substance, such as a piece of car-





tilage, or half of a pea, had been introduced into the substance of the skin. (See Plate II. fig. 5.) This induration depends upon the effusion of lymph into the areolar texture of the skin, or into the cellular tissue below the mucous membrane; and when it is considerable, the part is raised above the surrounding surface, and then gives rise to the variety of ulcer which has been called the *ulcus elevatum*.

This induration has no doubt often been confounded with the infiltration which surrounds the phlegmonoid variety of the suppurating sore, and with that produced by accidental irritation; but in the great majority of cases it may be distinguished by its abrupt termination, and by its equal consistency throughout. Another form of disease, from which it is not so easily distinguished, is the secondary induration, which may form part of the constitutional symptoms of syphilis. This secondary induration may show itself in the same parts as primary infecting sores, and may, like them, be accompanied by induration. In both cases the induration depends upon plastic effusion from a specific cause; in both, this has a tendency to assume, more or less, the tubercular form; and in both, the induration may terminate abruptly. In general, however, this defined outline is more marked in the primary than in the secondary form of the disease.

It will sometimes happen when there is great induration that the circulation through the part does not readily take place. The surface of the sore may then slough to a certain extent (Plate III. fig. 6), but this will not prevent the appearance of secondary symptoms.

Syphilitic infection does not manifest itself immediately upon the application of the poison; a period of incubation follows the inoculation, during which nothing is perceived, and the patient thinks himself well. From ten days to seven weeks after the application of the cause the primary disease will manifest itself. In the interval there may possibly be some other venereal affections, such as arise from the contact of impure secretions, but the characteristic symptoms of the syphilitic infection will not appear until after the period of incubation above named. There is, however, one remarkable exception to this rule, and that is with regard to the re-inoculation of the secretion of an infecting sore soon after its first appearance. At that time the inoculation will succeed much more quickly, and the induration which follows will be sooner developed. It has been said that if a person be inoculated with the vaccine matter on several successive days, the vesicles will all arrive at maturity about the same time. Now, something like this obtains with regard to syphilitic infection. If a person becomes infected, and a sore appears some three or four weeks afterwards, and some of the secretion from that sore be immediately re-inoculated, the inoculation will probably succeed, and the induration of the two sores will then appear about the same time. After the characteristic induration has been established, the infecting chancre is no longer capable of being re-inoculated; but for a considerable time, if fresh action be excited in the part, as, for instance, by the application of a blister, a secretion may be obtained which is re-inoculable upon the patient himself. The inoculations thus produced do not resemble in their course the results of inoculations on a patient who has not previously been infected. They have no period of incubation. They are not accompanied by induration. They rarely ulcerate; and if a sore forms, it soon heals. The stains, however, of these inoculations from an irritated infecting sore may last for weeks or for months.

Some very remarkable statistics have been produced on the subject of the re-inoculation of the secretion from infecting sores. In 1855, M. Clerc announced the doctrine, that this secretion could not be inoculated—a theory which corresponded with, and might have been deduced from, Ricord's dogma, that a person can have syphilis once only. As the indurated sore was said to be the necessary precursor of constitutional syphilis, and as syphilis was supposed always to follow an indurated sore, it followed that, when once the constitutional affection was established, the patient's system in which it was so established would no longer be capable of being re-inoculated so as to produce again the same disease. In 1856, this point was experimentally tested in the Lock Hospital, and the results are recorded in the British and Foreign Medico-Chirurgical Review for the same year. It was then found that the indurated chancre was not capable of being inoculated upon a patient whose system was already syphilized in the proper acceptation of the term.

In 1856, M. Fournier also inoculated a hundred patients from their own infecting sores, and succeeded in his experiments once or twice only. His results were not published until 1858.

M. Rollet, in his recent work, mentions having inoculated two hundred patients who had infecting sores with the secretion of their own chancres. He found that those in whom the inoculation succeeded were six per cent. These sores were said to be *auto-inoculable*. In the remainder the inoculation failed.

Now, Fournier's experiments and Rollet's experiments coincide in a wonderful

manner with practical statistical details as carefully observed. During the years 1855–56, I kept an accurate register[1] of such cases, and out of one hundred that had been diagnosed as suppurating non-infecting sores, secondary symptoms followed, as far as I was able to ascertain, in two instances only. Out of so large a number, the proportion is curiously in accordance with the exceptions in Fournier's and in Rollet's experiments. The exceptions in all three series of observations may be attributed to the same cause—a *twofold* inoculation may in all the instances have taken place and produced the suppurating local syphilitic affection as well as the infecting chancre. (See Plate III. fig. 7.) The former had probably in Fournier's and in Rollet's exceptional cases furnished the inoculable pus, and had, in my own observations, masked the characters of the affection that I was attempting to diagnose. This conclusion is confirmed by the results of the inoculations as far as the experiments were concerned. The affection produced by the inoculation from the supposed indurated sores was, not an indurated sore of the same nature, but a *pustule*, the characteristic origin of the local suppurating disease. Practically, then, we conclude that if a syphilitic sore yields a secretion, capable of being inoculated so as to produce the specific pustule, the evidence, so far as it goes, is in favor of its being a local disease, and not requiring constitutional treatment. If, on the contrary, a disease which we believe to be primary syphilis yields a secretion which is not auto-inoculable, then the evidence is against the local character of the affection, and indicates a constitutional mode of treatment in order to prevent or to mitigate the secondary symptoms.

A few years only have elapsed since the test of a really syphilitic sore, and the propriety of giving mercury for its cure, was supposed to be its auto-inoculability. This doctrine was upheld even in some of our most widely-circulated works on the subject of syphilis. But, as now shown, the idea was not only an unsafe guide scientifically, but it was practically the very reverse of the truth. The confusion which thus arose was one of the many natural results of some of our leading authorities, both here and on the continent, having confounded together, and mixed up in their descriptions, the two varieties of syphilitic disease. These are now, it is hoped, sufficiently clearly distinguished, never again to be confounded.[2]

In a well-marked infecting sore, the edges are firmly adherent to the subjacent and surrounding tissues. (See Plate II. fig. 5.) They are smoothly bevelled off, or rounded so that the well-defined sharp edge noticed in the description of the primary suppurating sore is here wanting. The surface of the infecting sore varies in color. It sometimes presents a fawn color; at other times it is uniformly red; at others, again, portions of adhesive matter of a grayish color will be seen on its surface. These different appearances depend upon the accidental circumstance of the separation, or otherwise, of a portion of the plastic exudation which forms the thickened base of the sore.

Besides the nature of the secretion, and the auto-inoculability of that secretion, there is another diagnostic test of very great value in distinguishing primary syphilitic infection, and that is the condition of the corresponding inguinal glands.

In the previous section we saw that some of the material involved in the local suppurating form of the disease might be conveyed through the lymphatic vessels, and again reproduce its particular morbid action either in the lymphatic vessels themselves, or in the inguinal glands, and we regarded this as a kind of re-inoculation, or as a translation of the disease by a natural process from one locality to another; and it has been shown in the present section that during the early stage of a syphilitic infection the part first contaminated produces a secretion which is auto-inoculable. These two circumstances will prepare us for understanding the pathology of the chronic indolent enlargement of the glands which constantly attends a syphilitic infection.

The part first inoculated, as we have seen, takes on the adhesive form of inflammation. If some of the secretion from this infected spot be inoculated with the point of the lancet before the specific adhesive action develops itself, both inoculated points will become similarly affected; and if by a natural process the same thing be effected—if a portion of the contaminated matter be conveyed along the lymphatic vessels—then at the point where such matter is arrested the specific adhesive action will take place.

[1] Cases regarded as doubtful or mixed were not included in this table.

[2] The distinction between the two kinds of disease in their mode of *origin* was first recognized in 1854. In my Pathological and Surgical Observations, published in that year, the local disease, which commences with a suppurative form of inflammation, is described as a morbid process, distinct and separate from the specific adhesive action which is followed by constitutional symptoms. That the auto-inoculability of a chancre was evidence of its non-infecting character, was first pointed out by me in the British and Foreign Medico-Chirurgical Review for 1856.

Thus both forms of the syphilitic disease are auto-inoculable: the suppurative form during its whole continuance; the adhesive form during its early stage only, before the specific hardness has appeared. Each form of syphilis is capable, by natural auto-inoculation (or by lymphatic absorption), of being conveyed to the inguinal glands, and of there reproducing its specific and peculiar action. It would appear, however, that in the suppurative form of the disease, in which the discharge is soon thrown off from the surface, lymphatic absorption does not so generally take place as in the specific adhesive action, where the infected tissue remains often for months as a portion of the living structure of the part. In the suppurating form of the disease lymphatic absorption by no means always occurs. It is the exception, and not the rule; and when it does occur, one gland only is generally affected; whereas in the adhesive form of the disease, the inguinal glands are almost always involved, and in general there are several affected at the same time. This has caused the name of *multiple indolent bubo* to be given to this specific affection of the inguinal glands: a condition very surely indicating that the patient's system will shortly be, if it is not already, infected.

The characters of the inguinal glands attacked with specific adhesive inflammation are peculiar. The affection appears at, or about, the same time as the specific induration. This peculiar form of auto-inoculation occurs, therefore, at the same period at which the chancre might be inoculated by the lancet upon another part of the same patient's skin.

After an indurated chancre has ceased to be auto-inoculable upon the skin, it probably ceases to furnish any matter to the absorbents which can cause their specific induration. The suppurating syphilitic sore, on the contrary, which furnishes a secretion which is auto-inoculable during its whole existence, may also at any period of that existence give rise to a suppurating bubo.

Sometimes one gland only is involved in a case of syphilitic infection; but generally there are several. Each gland becomes enlarged without causing any pain or inconvenience to the patient, and without his being aware that anything unusual is taking place in the part. The enlargement is confined to the gland structure itself, and does not involve the surrounding cellular tissue. Each tumor may become the size and shape of the dried shell of an almond; and I have been in the habit of describing this peculiar affection as the *amygdaloid* condition of the inguinal glands. Each separate gland may be felt rolling in its bed of loose cellular tissue, and the unaffected skin will move freely over it. These glands are very hard, and give very much the same sensation to the touch as the induration of a primary chancre. The peculiar hardness depends upon the fact that this newly effused plastic material is confined to the gland, and accurately circumscribed by its capsule.

Lymphatic glands affected with specific induration do not suppurate. When the disease is uncomplicated this may be received as a universal rule. Yet in practice we every now and then hear of buboes suppurating in connection with infecting sores. Some of these are scrofulous buboes; some are buboes arising from some accidental cause of irritation; and some are buboes which occur upon the accession of secondary symptons, and in consequence of some eruption on those parts of the skin, whence the lymphatics which empty themselves into the glands arise.

When all these sources of error in diagnosis have been guarded against, there will still remain a few cases in which an infecting chancre has apparently given rise to a suppurating bubo. The number of such cases has not been ascertained statistically, but they are very few indeed, and probably not even so great in proportion as the cases in which an infecting sore retains its auto-inoculability after the development of its specific induration. The exception in both classes of cases depends, in all probability, upon the same cause—namely, a twofold inoculation upon the same part.

A very remarkable circumstance remains to be noticed with regard to lymphatic absorption, both from the suppurating sore and from the primary infection. The glands into which the absorbent vessels directly enter are those only which are affected. These are called the glands *first in order*. The glands *second in order* —that is, those glands which receive their lymphatic vessels only from other glands, are never affected with the specific action peculiar to any form of primary syphilitic disease. It is evident, therefore, that no form of syphilitic action can find access to a patient's system through the lymphatics. The specific action ceases with the first system of glands with which the affected matter is brought in contact, and therefore the affection of the lymphatic glands may be looked upon as a part of the primary symptoms. An inguinal gland affected with specific induration would, no doubt, if no other cause of infection existed, produce constitutional disease; but it would be by means of the blood that circulates through its diseased structure, and not by the passage of the poison into the circulation through the thoracic duct. In the same way a

chancre infects a patient's constitution by the morbid action communicated to the blood circulating through its texture, and not by lymphatic absorption.

When once the general system of a patient is affected with syphilis, the same disposition to the effusion of plastic matter may occur in any situation as was manifested at the original seat of the disease. This disposition to plastic effusion may be traced in every stage of the disease. We have considered it in the primary infection, and as giving rise to the peculiar characteristic induration of the lymphatic glands. In the secondary forms of the disease the same action may also be traced in effusion of lymph upon the iris ; in the deposit of tubercles in the cellular tissue and in various internal organs ; in nodes upon the bones ; and in various kinds of papular and tubercular eruptions upon the skin. All these different forms of secondary disease may be referred to the same tendency to plastic effusion ; the effused material, if allowed to remain, being influenced by, and becoming part of, the structure in which it occurs.

In the treatment of syphilitic infection, after the disease has manifested itself, cauterization is of no avail, as far as the prevention of constitutional symptoms is concerned. The period of incubation which has already elapsed forbids the idea that the poison can then be destroyed by the application of caustic to any particular part. Practically the same truth is found unfortunately to be but too evident. Infecting sores, that have been destroyed on the very day of their appearance, have subsequently continued to spread, and have produced their natural consequence. Even if an infecting sore be cut out, the infection of the patient's system will not thereby be prevented. The diseased action has already spread to other parts, and has already perhaps commenced in the lymphatic glands before any visible indication of its existence presents itself. A sustained, judicious, and constitutional mode of treatment is the only one that can be relied upon in the treatment of this disease.

[In addition to the varieties of syphilitic initial sclerosis, enumerated by the author, should be named herpetiform and diphtheroid chancres. The former is more probably a result of accidental inoculation of the lesions of simple herpes progenitalis. The latter becomes indurated and capped with larger or smaller ulcers. They are naturally multiple, and it should be noted in passing that infecting sores are more frequently multiple at the outset than has hitherto been believed. The "diphtheroid of the glans"[1] is an adherent, glistening, grayish-white, leathery, uniformly thickened hood, slightly elevated and greasy to the touch, embracing the glans and unaccompanied by induration. It is the precursor of constitutional lues. Cases of so-called "mixed chancre," partly described in the seventh section of this essay, exhibit features of both varieties of venereal sore, coincident or successive, the order of symptoms being that required by the occurrence of a period of incubation for the syphilitic sclerosis. Chancres of the lip, usually resulting from contact with secreting mucous patches, are pea- to chestnut-sized masses of sclerosed tissue, surmounted by superficial abrasions or deep and ragged excavations, accompanied by sub-lingual or sub-maxillary adenopathy. Chancres of the nipple are important, not only clinically but in a medico-legal sense, and may occur at the summit of the organ, at the base, or in the areola, as slight indurated excoriations, infiltrated fissures, dry or moist papules, or deeper ulcerations. These extra-genital lesions are all apt to be livid from pigmentation or blood-stasis, and, being preceded by the usual incubative period, furnish a clue to their character in their history. Chancres at the urethral orifice are usually irritative from the passage over them of the urinary current, and, becoming phagedenic, leave the glans blunt and square-shaped—a characteristic deformity in the male. Intra-urethral chancres rarely occur deeper than two inches from the meatus, and have been recognized by the aid of the endoscope. They are accompanied by very scanty urethral discharge, not to be confounded with that of blenorrhagia, and can be readily recognized through the external tissues of the male organ by their characteristic sclerosis.

Pathologically, Kaposi[2] has discovered in chancre-sections, cell-infiltration in a narrow-meshed network of thin, distinctly outlined connective-tissue fibres. At the surface there is irregular exposure of the elements constituting the sclerosis, with débris of protoplasmic bodies which make up the secretion. The deformed papillæ persist only at the margins of the sore ; and the vascular elements, where the tissue is thickened, are scanty, with diminished lumen from encroachment of walls. The author admits that only in the matter of rapidity and extent of the hyperplastic or degenerative processes, can a distinction be established histologically between the two varieties of venereal sores.]

[1] Morrow. Archives of Dermatology. New York, 1876, vol. ii. p. 383.
[2] Loc. cit.

IV. Lymphatic Absorption.

Physiologists have usually recognized three modes by which absorption may take place :—

I. That by which foreign substances find their way directly into the blood through the coats of the bloodvessels.

II. The absorption of the chyle from the mucous surface of the intestines by the lacteals.

III. Absorption by the lymphatics.

To these three modes of absorption, by all of which extraneous substances have been supposed to enter the circulation, we may add a fourth means by which the system may be influenced by the action of some kinds of poisons; namely, that in which a direct local effect is produced upon the nerves of a part, and through them upon the brain (and consequently upon other organs), without the poisonous material being taken into the blood.

Examples of this mode of the action of poisons are afforded by the effects of the juice of the leaves of the aconite, and of the infusion of tobacco, as illustrated in some of Sir B. Brodie's physiological experiments.

In most instances the action of a poison commences immediately upon its application. But in the case of morbid poisons, a certain interval must elapse, and a certain morbid process must be gone through, before these can produce their specific action upon the general system.

The deleterious materials of which these poisons essentially consist, or the secretions in which they are contained, may be applied to the living body in any quantity, and for any length of time; and unless the process, which is peculiar to each of them respectively, be gone through, its characteristic effects will not as a rule be produced upon the constitution.

If the particular action by which these poisons individually enter the system be disturbed or interfered with—so as not to be carried out—other results may follow, but their full general and specific influence will not be experienced. If the first step in the process be defective, so will be its natural consequences.

The knowledge which we thus obtain furnishes us with a most important power; for, by modifying or altering the morbid process by which a poison enters the system, as, for instance, by the early application of caustic to the infected part, we may, under certain circumstances, modify or control its effects.

I purpose now to consider how far the action of the syphilitic poison upon the constitution may be thus modified or controlled, by the kind of action which is produced when it is first applied to the living tissues of the body. For this purpose it is requisite to consider what the morbid actions really are by which the syphilitic poison gains an entrance; and what the natural processes are by which it joins itself to, and becomes as it were incorporated with, the living being.

The opinions of Hunter on the absorption of the syphilitic poison have given a bias to all subsequent reasonings upon the subject; and the theories based upon his experiments are very generally received, even up to the present time. He demonstrated, as he believed, that the lymphatic vessels were the true absorbents; and he concluded from his discovery that they were the *only* absorbents in the system.

The experiments upon which his idea was founded deserve attention. Assisted by his brother and several other eminent medical men, he confined some warm milk in a portion of small intestine; and having tied the artery and vein which supplied the intestine, he saw, as he believed, the lacteals of the part presently become filled with the white milk. Upon puncturing the vein upon the distal side of the ligature, it was soon (by pressure of the finger) emptied of its blood. No white fluid could, during the continuance of the operation, be found in the vein. Upon a repetition of the experiment, in which the circulation through the mesenteric vessels was left free, the blood in the vein was carefully examined and compared with that in the neighbouring veins, but it was found not to be light-colored, nor milky, nor could any difference whatever be detected in it. It was found that even by firm pressure, which was continued until the intestine burst, the milky fluid could not be made to pass into the veins.

In another animal, some thin starch, colored with indigo, was introduced into the small intestine, and the lacteals were soon afterwards seen of a fine blue color. A vein in this part of the mesentery was opened, and the blood which flowed was allowed to separate into coagulum and serum. The next day the serum had not the least bluish cast.

An injecting pipe was then fixed in an artery of the mesentery, where the intestine was filled with blue starch; and all communications both in the mesentery and intestine were closed, with the exception of the vein corresponding with the artery. Warm milk was now injected until it returned by the vein. This was continued until all the blood was washed away, and the vein returned a bright white milk. The milk thus circulating through the intestine containing the blue starch was not in any degree changed in color.

In a third animal, some musk in warm water was confined in a portion of the intestine; after waiting a little time, some of the lacteals of the part were opened with a lancet, and some of the watery fluid which they contained was received into a small spoon. This was thought to smell strongly of musk. Some blood received into a clean spoon from one of the veins of the same part had not the least smell of musk.

From these and similar experiments, Hunter arrived at the inference, which must have appeared one of the greatest discoveries of his age, *that the veins do not absorb in the human body.* It necessarily followed from this that the lymphatics were to be considered as the only absorbents; and this is stated by Hunter to be the fact, in his work on the venereal disease.

If the lymphatics were the only absorbents, they must of necessity have been looked upon as the only channels through which poisons could, under ordinary circumstances, enter the system; and accordingly we find Hunter asserting that the venereal matter is taken up by the absorbents of the part in which it is placed, and carried along the absorbent vessels to the common circulation.

This view, deriving as it does such an apparent confirmation from the frequent occurrence of inflammation of the lymphatic glands in venereal diseases, was adopted with more or less modification by almost all the writers on syphilis who followed Hunter.

The accuracy of the experiments upon which Hunter based his theory has, however, justly been doubted by other physiologists; but the theory itself, as regards the syphilitic poison, was up to a recent date, strange to say, scarcely questioned.

MM. Tiedemann and Gmelin, after mixing various substances, which might easily be detected, with the food of animals, not unfrequently found unequivocal traces of these substances in the venous blood and urine, whilst it was only in a very few instances that traces of them could be discovered in the chyle.

In repeating Hunter's experiments, Mayo found that half an hour after a solution of starch and indigo had been placed in the cavity of the intestine, the lacteals appeared of a clear blue color; and those present were for a time satisfied that the indigo had been absorbed. But upon placing a sheet of white paper behind the mesentery, it was found that the blue tinge had disappeared. On removing the white paper the vessels reassumed their blue color. It became, therefore, evident that the blue tinge was the natural color of the empty lacteals; that while they continued to absorb the chyle they were white, but that as soon as they were simply empty they appeared blue.

Thus a repetition of the Hunterian experiments rather tends to prove that the function of the lacteals is limited in the absorption of chyle: and that the lymphatics are not the only absorbents, appears most conclusively demonstrated by the experiments of MM. Magendie and Ségalas. M. Ségalas varied Hunter's experiment in the following manner: A fold of small intestine was drawn out of a wound in the belly of a dog; all the bloodvessels passing to and from it were tied, with the exception of one artery; a vein punctured upon the mesentery allowed the blood to escape, which would otherwise have stagnated in the part. The lacteal vessels and nerves were left entire. The fold of intestine was then tied at both extremities, and an aqueous solution of the alcoholic extract of nux vomica was poured into it. During the hour which followed, the poison produced no symptoms. The ligatures being then removed from one of the veins, the blood was allowed to return in the natural course of its circulation. In six minutes from this time the poison took effect.

The experiments of M. Magendie illustrating the same point are well known.

The thigh of a dog was separated by M. Magendie from the body, by a division of every part, with the exception of the artery and vein; into each of these vessels a quill was introduced and tied by two ligatures; between these ligatures the vessels were divided, and thus all communication was cut off between the body and the limb, except that which was maintained by the circulation of the blood. Two grains of the upas tieuté were then inserted into a wound in the foot of the separated limb. In about four minutes the poison manifested its effects upon the system.

From these and other facts, it appears certain that Hunter's idea of the lymphatics being the only absorbents is incorrect; and we are thence naturally led to the consideration of the value of the theory of the mode of absorption of the syphilitic poison, which was based upon that notion.

When lymphatic absorption takes place in connection with a suppurating syphilitic sore, the action of the poison may be traced in the clearest way along the absorbent vessels. In any part of its course, the poison may inoculate the vessel in which it is contained, and may produce a fresh syphilitic sore, the secretion of which may again be inoculated. It usually happens, however, that the inguinal gland in which the absorbent vessels terminate is the part affected. Here alone, in the great majority of cases, does the poison

exercise its influence upon the absorbent system; but that the poison actually passes, as such, through the absorbent vessels, we have abundant proof in the specific effects of the poison in the course of those vessels. Between the lymphatic gland and the primary disease, a small abscess will occasionally form. This will present tumid and irritable edges, will afford all the characteristics of a suppurating syphilitic sore, and will furnish an inoculable secretion. We can then distinctly trace the entrance of the syphilitic poison into the lymphatic vessels, and from them into the absorbent glands in which these vessels terminate. The actual existence of the virus in any part of this course may be demonstrated by experiments, which have been far too often repeated to require any additional confirmation. Arrived at this point of its course, on its way apparently towards the thoracic duct, and from thence to the general circulation, what becomes of it? A very wonderful change is here brought about. The specific virulent poison, which before was liable to contaminate every living part that it came in contact with, cannot be traced beyond this point. The absorbent vessels between the inflamed gland and the thoracic duct do not ulcerate or suppurate; the glands into which they empty themselves do not become enlarged or inflamed. The influence of the poison is here then gone. Beyond the glands first in order, the fluids which the absorbent vessels contain are bland and harmless, incapable of being inoculated, or of infecting any part with which they come in contact. What then has become of the poison? We find it in the vessels going into the inflamed absorbent glands, but we do not find it in the vessels which proceed from those glands. In a certain number of cases, no doubt, the poison is in great measure discharged in the suppuration to which its presence gives rise. But, when we consider the exceedingly minute quantity of an animal poison that is capable of producing its specific action on a part, this explanation is not sufficient. Some of the fluid or particles which enter the gland must, in some form or other, we should think, pass through it, whether it suppurate or not. Even although we should suppose that the inflammation produced in the gland entirely obstructed its channels, still, before such obstruction could take place, some fluid would surely have time to pass; and this, if its quality remained unchanged, would be sufficient to inoculate any part with which it came in contact, or to infect the general system.

A similar series of phenomena may be observed in the affections of the lymphatic vessels which accompany an indurated primary syphilitic sore, with the exception that the action in the glands is of the same nature as that which constitutes the primary disease. The poison taken up by the lymphatics may, during the earliest stage of the disease, inoculate a lymphatic vessel; and it almost always inoculates one or more of the lymphatic glands, so as to produce in them exactly the same kind of disease as existed in the part from whence the morbid material was derived. But beyond the lymphatic glands first in order, no farther effect is produced upon the lymphatic vessels. The fluids which they contain are bland and harmless, and afford no indication of containing any poisonous or irritating ingredients.

Up to this point, then, we have unequivocal evidence of the presence of the syphilitic poison, and of its power of contaminating fresh parts. Beyond this, the poison can no longer be traced. The fluids in which it was before contained now neither possess the power of irritating the vessels through which they pass, nor, when extravasated from these vessels, of infecting other structures. Here, then, some wonderful change is produced. The specific characters of the poison can no longer be detected either by its morbid effects, or by inoculation. Even Hunter noticed this circumstance. He says, "we never find the lymphatic vessels or glands that are second in order, affected." And he remarks, that when the disease has been contracted from a cut upon the finger, he has seen the bubo come on a little above the bend of the arm, upon the inside of the biceps muscle. In such instances no bubo has formed in the armpit, the most common place for glands to be affected by absorption.

Virchow has noticed the same point. In speaking of the occasional introduction—or intravasation, as he terms it—of pus and other diseased products into venous and lymphatic vessels opened by abscesses and ulcers, he remarks that the transit of pus by lymphatic vessels is not at all uncommon, but he contends strongly against the production of general pyæmic infection by this means. "All the lymphatic vessels," he says, "which are in a condition to take up pus in this way are peripheral ones, whether they arise from external or internal parts, and only after a somewhat lengthened course do they gradually reach the bloodvessels. In all, interruptions are formed by the lymphatic glands; and since we know that the lymphatic vessels do not pass through the glands as wide, tortuous, and interlacing canals, but that, after they have broken up into fine branches, they enter into spaces which are filled with cellular elements, it is manifest that no pus-corpuscles can pass a gland." This very im-

portant point of view, although it meets with the best possible confirmation in the daily experience of the practical physician, is generally overlooked, as Virchow conceives. He instances the process of tattooing. However minute the subdivision may be of the substances introduced, we never find these conveyed beyond the nearest lymphatic gland. In proof of this statement, Virchow adduced an example in which substances, introduced for this purpose by a soldier fifty years before, had not penetrated farther than the nearest lymphatic gland, as proved by microscopical examination of the parts.

Although, as he remarks, these glands act as a filter, in mechanically retaining the coarser particles contained in the current of fluid passing through the glands, that is not by any means their whole office. "They have manifestly another part to play, inasmuch as the substance of the glands indubitably takes up into itself certain ingredients from the fluid mass of the lymph, retains them, and thereby also alters the chemical constitution of the fluid, so that it quits the gland all the more altered, because it must at the same time be assumed that the glands yield up certain constituents to the lymph, which did not previously exist in it." Virchow illustrates these statements by an appeal to ordinary phenomena observed in cases of malignant tumor and syphilis. "When an axillary gland becomes cancerous, after previous cancerous disease of the mamma, and when, during a long period, only the axillary gland remains diseased, without the group of glands next in succession, or any other organs becoming affected with cancer, we can account for this upon no other supposition than that the gland collects the hurtful materials absorbed from the breast, and thereby for a time affords protection to the body; but at length this protection proves insufficient; and perhaps at a later period the gland itself becomes a new source of independent infection to the body, and a further propagation of the poisonous matter may take place from its diseased parts."

Neither observation nor experiment, then, affords any proof that the syphilitic virus is conveyed, as such, through the absorbent glands; all the direct evidence which we have points to an opposite conclusion. The particles in which the poison resides here undergo some change, become perhaps disintegrated, and after that process the effects of the poison in the lymphatic vessels appear to cease.

The evidence upon which it has been assumed that the syphilitic poison enters the system through the absorbent vessels must, therefore, be regarded as most inconclusive. Arrived at the first lymphatic gland which it meets, and there undergoing some change, it becomes incapable any longer of producing its specific effects; and we cannot therefore admit that this is the way in which the system becomes infected after the specific primary adhesive action.

If we reflect upon the different ways in which foreign substances can be taken into the living body, we shall find that every such way is furnished with certain sentinels or guards, which oppose the entrance of materials which, if admitted, would prove injurious. Whenever any irritating matters are applied to the skin, which might, by being absorbed, become injurious to the system, the delicate sense of touch informs us of what is going on, and urges us to get rid of the offending material. This is a sense common to the whole body. But the parts through which foreign matters are usually taken into the system are guarded in an especial manner. Thus, in addition to the sense of touch, we see the mouth guarded by the sense of smell and that of taste: three out of five senses concentrated around the opening by which the food enters into the system; and one at least of the other two always ready to assist in affording information of its nature. If we trace the food onward, we find that it has to pass the double row of teeth, which are acutely sensible to the presence of any hard particles that may have become accidentally mixed with it. Should any fresh flavor be produced in the process of mastication, there are the means provided for appreciating it as the food passes through the posterior fauces. The stomach we find ready, in its turn, to reject that which is injurious; and throughout the alimentary canal there is an apparatus composed of a multitude of different parts, all combining to hurry on and eliminate from the system any materials which, if left, would be detrimental to it.

Finally we have a wonderful system of minute capillary tubes (endowed with the faculty of distinguishing, so to speak, the chyle from other matters), taking up, and pouring freely into the blood, that which is required for the nourishment of the system, but refusing to admit anything else. These lacteals are very similar indeed in structure, in disposition, and in function, to the absorbent vessels elsewhere. It is true that we cannot trace equally well the processes involved in the assimilation and absorption of the different individual organs of the body, as in the analogous actions which convert the food originally into part of the living being; but, from what we do know, we have abundant evidence that the same care is taken with regard to each part as with respect to the whole; and we have reason to believe that other channels, through

which foreign matters may enter the system, are guarded with the same care as that by which the common food is received.

Such facts would lead us to the *à priori* conclusion that some means must exist to prevent the indiscriminate introduction into the circulation of any materials which might find their way into the absorbents during the active ulceration of a part; and observation demonstrates to us that such a provision really exists. The particles taken up by absorption ultimately again form part of the general circulating fluid from which they were at first derived. They have as much to be assimilated as animal matter taken fresh into the stomach. The bone, the tendon, the muscle, the nerve, which are thus removed, can no longer be recognized as such after they have been acted upon by the absorbents. All the different tissues that undergo this process form a single fluid, which ultimately becomes a part of the general circulating mass, and can then in no way be distinguished from similar products derived from the process of ordinary digestion. The action which converts foreign animal matter into blood, and that which converts parts of the living body into blood by the agency of the absorbents, are then analogous; and they agree in having the very remarkable property of converting some substances, which when introduced in any other way act as poisons upon the system, into harmless agents. It has been shown by the Abbé Fontana, that the poison of the viper, when introduced into the stomach, undergoes some change which prevents its poisonous effects upon the system. It has also been shown by two French physiologists, that the same thing happens with regard to the woorara poison, and we have it upon no less authority than that of Sir B. Brodie, that opium may be digested in the stomachs of some animals, and that in that process its poisonous qualities are destroyed. "I have injected," says Sir B. Brodie, "a strong watery solution of opium into the stomach of a rabbit, but no poisonous effect was produced, although a similar solution, injected into the cellular membrane, occasions stupefaction and death." In like manner, we find that cancerous matter cannot be propagated from a part to the general system through the lymphatic glands; but we have evidence to prove that it may, under certain circumstances, be so propagated through the bloodvessels. It is true that the veins in the immediate neighborhood of a cancer are very frequently blocked up with coagula, affording another instance of the preservative power above mentioned; but when this is not the case, the cancer cells may apparently be conveyed in the course of the circulation and infect distant parts. We have an experiment on the authority of Langenbeck, related in the Encyclopédie Anatomique, in which some fresh cancerous matter was injected into the veins of a dog, and cancerous tubercles were consequently developed in the animal's lungs.

In like manner, I suppose, it might be possible, under certain peculiar circumstances, to infect the general system with cancer through the absorbent vessels; but the fact that the glands first in order only are affected in consequence of local cancerous diseases forbids the idea that this is the way in which the disease is usually conveyed to other parts.

These observations will enable us to consider on sound physiological principles the change that is produced in the syphilitic poison during the passage of the matters in which it is contained through the lymphatic glands. These materials are themselves undergoing a change which will fit them for becoming part of the circulating fluid, and it would seem that the poison also undergoes a change similar to that produced in the poison of a viper, or in the woorara poison, by the stomach.

The difference in the nature of the fluid in the lymphatic vessels, before and after it has passed the inguinal glands, is then analogous to the difference in the qualities of the woorara poison before and after it has undergone digestion in the stomach and lacteals. In both cases do the fluid contents of the lymphatic vessels undergo a change fitting them to become a part of the circulating fluid; in both cases are poisonous matters sometimes converted or assimilated, and sometimes rejected; by vomiting in the case of the stomach, by suppuration in the case of the lymphatics.

In looking over my notes of cases which presented themselves at the Lock Hospital during the year 1854, I collected together and arranged in a tabular form forty-nine consecutive cases of suppurating bubo. Of these, five only are recorded as having been accompanied, or followed, by any secondary affection during the period that they remained under observation. In one of these five there was a distinct history of previous disease, both primary and secondary. In another, the cervical glands were enlarged, and the suppuration in the groin may therefore probably have been of a strumous character. In two cases, the secondary eruption was tubercular—an affection most obstinate in its nature, very liable to recur after having once disappeared, and comparatively seldom occurring as the first symptom of cutaneous disease. These, then, I regard in all probability like the first of the five cases, as the result of some previous syphilitic infection.

This analysis would thus leave only one case out of forty-nine in which a disease which produced a suppurating bubo also produced secondary syphilis.

On the other hand, I collected and tabulated in the same way thirty-one consecutive cases of secondary syphilitic eruption. In only one of these cases does the history afford any mention of a suppurating bubo, and in that one case the history is not satisfactory upon the point. Such facts appear to establish indisputably the proposition that the chances of the infection of the system in cases of syphilis are inversely in proportion to the degree of irritation and inflammation of the absorbent vessels leading from the primary seat of disease.

Physiological absorption.—Hunter believed that the syphilitic poison might be simply absorbed by the vessels of a part, without giving rise to any local affection; and ever since his time there have been original observers who have held the same doctrine. Thus Mr. Lane, one of the present consulting surgeons of the Lock Hospital, has shown, by inoculation, that a bubo was of a specific character, when no primary lesion could be found upon the most minute examination; Dr. Marston, of the Royal Artillery, has lately recorded cases in the Transactions of the Royal Medical and Chirurgical Society, in which constitutional syphilis occurred without any previous primary symptom, and cases have occurred in my own practice in which every effort has been made to discover a primary lesion in cases of constitutional syphilis without any such being detected.

V. Destructive Syphilitic Inflammation: Phagedæna: Serpiginous Sores.

Destructive Syphilitic Inflammation.

It is a very remarkable fact that some of the most vascular parts of the body, and those the best supplied with nerves, are, under certain circumstances, the most prone to mortification. The parts of generation, amply supplied with nerves and bloodvessels, will, under the influence of the syphilitic poison, occasionally become intensely inflamed, and that inflammation will speedily terminate in gangrene. If the gangrene so produced occurs within a short time after the application of the syphilitic poison, the death of the part involves the destruction of the poison. They together cease to exist; and, when the slough separates, an ordinary sore alone remains, requiring no specific treatment.

Mortification of some part of the organs of generation sometimes appears to depend upon a diseased state of the blood, independent of any local cause. The blood will stagnate in the capillaries of the skin here as elsewhere; and the tendency to mortification will first show itself in the most vascular parts. The skin will be affected before the areolar tissue, and the areolar tissue before the fibrous and membranous parts.

I. The mortification, which involves the whole of the membranous tissues, will sometimes be of the dry kind, but generally it will be of the moist variety. In the first there will be little pain or swelling, but in the second there will be much effusion, with great pain and a considerable amount of constitutional disturbance. Both these varieties of mortification may occur where there is no evidence of the disease having arisen from the application of any poison; and, on the other hand, they will occasionally as evidently appear to depend upon direct contagion. Patients in apparent health will sometimes, within three or four days after exposure, find some part of the organs red, swollen, and extremely painful. In the centre of the inflamed part a dusky spot will indicate that the blood has already begun to stagnate in the vessels. The nutrition of the parts is no longer maintained; irregular excavations are made by small portions of the tissues being thrown off in the sanious discharge. The whole part affected becomes of a darker hue, and ultimately presents the ordinary appearance of gangrene. After a time a line of demarcation is established, the slough is thrown off, and the wound generally cicatrizes without difficulty. This process, effected by nature, is very similar to that which is artificially produced by the application of caustic to a syphilitic sore. In both cases, if the mortification has reached all the parts which have imbibed the poison, the destruction of the poison will take place in that of the tissues which contained it.

In this first practical division of mortification, viz., that in which the whole of the infected tissue perishes, as it occurs naturally, there is very seldom indeed any subsequent affection of the patient's system, even supposing he has been in a position to contract an infecting sore; and the reason of this doubtless is, that the action which terminates in mortification commences at the same time as, or very soon after, the application of the poison. In cases where the mortification has been artificially produced, on the contrary, a period of incubation may have existed, of some days or weeks, before the disease has shown itself, and consequently before the caustic is applied: and during this

Fig. 6.

Fig. 7.

T. HUNTER, LITH. PHILA.

time the tissues will have imbibed the poison to a greater extent than the caustic can reach.

The morbid action, which we are now considering, appears to be communicable by contact, although this cannot be so closely traced as in the other forms of syphilitic inoculation. In patients, for instance, in whom the general health has not been impaired, parts which have no direct connection, either by bloodvessels or nerves, will appear to infect each other. Thus the glans and the prepuce, the opposed surfaces of the labia or of the nates, will sometimes become affected in a similar manner and exactly to the same extent; and when lymphatic absorption accompanies the gangrenous inflammation, the destructive action is tolerably sure to be communicated from the primary sore to the corresponding inguinal gland, and from it to the surrounding areolar tissue and skin.

II. The second form of destructive inflammation is by far more common, and ordinarily of much longer duration. In it the infected tissue dies slowly, bit by bit, by a kind of molecular necrosis; and, in consequence of this tardy action, the whole of the infecting portions never perish at the same time. A part is always left as a focus of contagion, and this involves fresh portions, which, in their turn, are thrown off, but not before they have communicated the disease to parts beyond.

This action constitutes the *phagedænic* syphilitic sore. It may appear as an original disease, or it may supervene upon any of the forms already described. It is inoculable, and generally arises from the direct result of the application of the syphilitic poison; but secondary forms of syphilitic disease may assume precisely the same characters. These, however, cannot readily be inoculated upon the patient, whereas the primary phagedænic ulcer can.[1] (See Plate IV. fig. 8.)

The phagedænic ulcer spreads irregularly in different directions, is accompanied often by much pain, and yields a profuse discharge. This consists of an ill-formed sanious pus, mixed up with the *débris* of organic tissues. It does not affect the inguinal glands, provided these have not become implicated before the phagedænic action has fairly set in; if they have, the bubo will probably open and present the same phagedænic appearance as the original sore.

There is one form of the destructive syphilitic inflammation which presents very peculiar characters. Instead of spreading from one point in a more or less circular form, the disease may slowly extend in the form of portions of circles, from several points at once; or, while the central portion first attacked heals, the affection will spread in a circular form, continually attacking fresh parts. The skin which is healed will then present a shining glazed appearance, surrounded by a dark-colored circle of irregular so-called ulceration. This affection has been named the *serpiginous chancre*. (See Plate IV. fig. 8.) Like every other form of chancre, it may be accurately simulated by a form of secondary disease, the capability of ready inoculation upon the patient who has it alone excepted. This affection spreads by a true necrosis; as one part heals, another becomes in succession red, livid, and disintegrated, the particles being thrown off in a thin sanious discharge. The loss of substance is occasioned entirely in this way, and not at all by the action of the absorbents. This form of destructive inflammation will sometimes continue for months, or even years; occasionally nearly healing, and then again, without any apparent cause, spreading in the same peculiar manner. It affects the folds of the groin, and the inside of the thighs and nates, perhaps more frequently than any other parts.

The destructive inflammation that occurs on the surface of an indurated chancre will sometimes present the same appearance for a short time as a soft phagedænic sore. This must be regarded as an accidental complication only, and not as a variety of the true phagedænic ulceration. (Plate III. fig. 6.)

A patient had a most obstinate serpiginous sore which defied all treatment. He was inoculated with different kinds of syphilitic matter. Nothing remarkable occurred from these inoculations: he was then inoculated with the secretions from his own serpiginous sores. The result of these inoculations was the production of sores exactly similar in character to those from whence the secretion was taken.

Upon each inoculated point a very well-developed and fully formed pustule appeared within the first few days. These pustules were depressed in their centres, and when they broke left exceedingly irritable ulcers. These ulcers were extremely painful, and surrounded by a deep red margin. A series of three sets of inoculations were performed, and the poison appeared quite as active and virulent at last as at first. Plate IV. fig. 9, represents the first inoculation which was made, on the sixty-second day of its progress;

[1] The experiment of inoculating this form of disease should be carefully avoided; for a surgeon can never tell when the artificial inoculation which he produces will heal, and he will have the credit of having prolonged the disease if the original sore should heal before the inoculation.

Plate IV. fig. 10, the exceedingly well-developed pustules resulting from the inoculations second in order, on the eighth day of their existence.

VI. Local Treatment of Syphilis.

Treatment of suppurating syphilitic sores.—The syphilitic poison requires a living nidus for its development, and a certain period must elapse before its specific action can take place. If, within the first five days of the application of the poison, the part to which it is applied be destroyed by caustic, the death of that part will determine the cessation of the morbid action. This cauterization, to be effective, must, however, extend to all the tissues which have imbibed the poison. It can, therefore, only be practised with success in the case of those chancres which appear within a very few days of the application of the poison. If a period of incubation have taken place, the tissues will so have imbibed the poison that it will be in vain to attempt to destroy all the parts that have been infected.

Suppurating sores generally make their appearance immediately upon the application of the poison; and to these, therefore, the method of treatment by cauterization is admirably adapted. For the purpose of securing the intended result, strong caustics should be used; and as these may sometimes extend further than is desired, it is always advisable, before applying the caustic, to have an antidote at hand, so as to limit its action when necessary. When the caustic has produced its requisite action, the antidote may be applied; this will have the effect of preventing the further extension of the caustic, and also relieve the pain to which it gives rise. Thus, if a strong acid be used, a solution of carbonate of potash, or chalk, will form a good antidote. If an alkaline caustic be employed, some vinegar may very conveniently be used to limit its action. When nitrate of silver is applied, the common olive oil is the best subsequent application.

The caustics most used for the purpose of destroying the suppurating syphilitic sores are the mineral acids, or a combination of potash and lime. The nitrate of silver will seldom extend sufficiently deep to eradicate the disease.

The strong nitric acid has often been employed, and acts extremely well; but it gives very considerable pain when applied to the surface of the body.

Another preparation which has been very much used is a combination of sulphuric acid and powdered vegetable charcoal. According to M. Ricord, when this preparation, in the form of a paste, is applied to a chancre, it dries quickly, and forms a kind of black crust, which remains adherent to the tissues, combines with them, and is not detached for several days. The wound will then be found to have lost its specific qualities and to be in a healing condition. The application of this caustic causes very severe pain, which lasts for a considerable period. The pain, however, is said to be less than that produced by the nitric acid; but then it does not admit of being relieved in the same way by the application of an antidote.

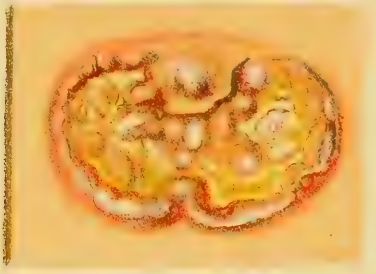
Perhaps the most convenient form of caustic is the potassa cum calce, as prepared in the shape of little rods for the purpose. The lime combines with the moisture of the parts, and prevents this from extending itself over the neighboring surface. The extent to which this caustic acts may therefore be regulated in the most accurate manner; and after it has done its duty, the application of some dilute acid will relieve the pain which it has caused.

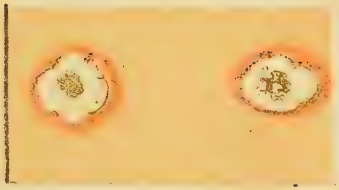
The actual cautery is a remedy which has often been successfully used for the phagedænic form of ulceration. The object with this, as with the other kinds of caustic, is to destroy the whole of the infected tissue, and *completely* to kill every part to which the cauterizing action extends. For this purpose the cautery should be heated to a white heat, and allowed to remain on the diseased part sufficiently long to destroy the tissues to the requisite depth. Phagedænic sores treated in this way have been known subsequently to present a healthy surface, and to heal without further trouble. Plate IV. fig. 8, represents a phagedænic sore which was destroyed in this way and subsequently presented a healthy surface (Cullerier).

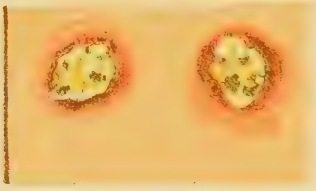
Serpiginous sores are often too extensive to be conveniently treated in this way. A modification of the plan may then be adopted. The outer edge of the sore may be alone destroyed, so that the diseased part may be completely surrounded by an artificial line of demarcation. This will sometimes prevent the extension of the disease. It will often happen that the edges of serpiginous sores are undermined, and if the cautery be then applied to the edges alone of the skin, it may not reach to the circumference of the disease. It is safe, under such circumstances, to destroy the skin deeply two or three lines from its detached margin.

The ordinary suppurating syphilitic sore, if not in its origin destroyed by caustic, will generally run its course, of five or six weeks' duration, and heal of its own accord, without leaving any injurious effects in the patient's general system.

It may be well, however, to use various







means to accelerate the healing of a suppurating sore, and such means are sometimes absolutely necessary.

So long as the sore has the specific characters of ulcerating deeply, with clearly defined vertical edges, it is well to continue the use of some mild caustic, such as a solution of nitrate of silver. When granulations spring up and the base appears healthy, it matters little what applications be used, provided the part be kept scrupulously clean.

The ulcer may assume the characters and appearances of similar lesions elsewhere situated; *e. g.*, it may be indolent, irritable, or inflamed, or, by granulating too redundantly, impede the cicatrization. Such symptoms are to be met by the same measures as would ordinarily be used.

If the chancres threaten to slough, it is best to dry the parts and apply nitric acid; afterwards using a lotion of potassio-tartrate of iron.

With a solution of that salt applied to the sore, and the administration of the same drug internally, the phagedænic action will almost always alter its character. Some intractable or phagedænic ulcerations are best treated by a mixture of one part of strong nitric acid to two, three, or four parts of distilled water; at other times a solution of carbolic acid, one part in forty, answers very well.

The common red wash of St. George's Hospital is an admirable dressing for phagedænic sores. It contains sulphate of copper, camphor, and Armenian bole. The last-mentioned substance prevents the lotion drying on the part.

In cases that threaten to spread, five or ten grains of the sulphate of copper may be used to an ounce of distilled water; but as this is likely to cause considerable pain, it is well to combine with it an equal quantity of opium, either in the form of powder or extract.

Solutions of sulphate of zinc or nitrate of silver (two grains to the ounce) are also often used.

When the acute form of destructive inflammation occurs soon after exposure to contagion, it must be remembered that the action which is taking place *may* save the patient's constitution from syphilitic infection. It would therefore not always be advisable to prevent that action entirely, even if we had the power of so doing; the object of treatment is to restrain it within due limits. For this purpose fomentations and poultices are generally sufficient as local applications. Leeches in considerable numbers have been recommended, but the ultimate benefit derived from them is doubtful: large and repeated doses of opium with an occasional brisk aperient furnish the best mode of constitutional treatment.

Of the buboes which attend and accompany suppurating chancres, two varieties may be mentioned. The progress of the first we can hope to arrest, while that of the latter will surely go on.

First. An inflammation of the lymphatics, such as often occurs after abrasions or wounds of other parts, may arise. The nearest inguinal gland may enlarge, and the textures seated upon it may inflame, without there being any specific material in the gland-tissue itself. If an abscess form, it is a simple abscess, and the ulcerated surface does not become a chancre, affording inoculable discharge.

Second. When lymphatic absorption occurs, there is a transmission and lodgment of a chancrous virus in the part. An abscess will then ensue, and the resulting ulcer will ofttimes be but a repetition of the chancrous process, and is to be treated, therefore, in a similar manner to the chancre.

When we have no means of deciding to which division the symptoms in the lymphatics are to be referred, it is well to try —by a few leeches, perfect rest, hot or cold applications, pressure, and the application of vesicants—to prevent suppuration. Of the latter the best are: the vesicant action by a strong solution of iodine, or painting the integument with a strong solution of nitrate of silver, dissolved with the aid of a little nitric acid, as suggested by Sir Henry Thompson. As soon as the effect of these remedies has subsided, pressure may be employed if the parts are still enlarged.

Should these plans fail in discussing the tumor, it is better to allow the patient to get up and walk about in the air.

Suppuration having set in, shall we open by multiple and small incisions, or by a depending one, involving the whole length of the swelling? The former course —with or without the use of stimulating injections—has proved very uncertain in its results; a free opening is generally to be preferred. The wound may then be dressed with strips of lint, from the bottom.

If the integument be thin and undermined, the action indolent, and the skin of a dull red color, opening the abscess by means of a liberal application of potassa fusa will be found to expedite considerably the subsequent healing.

When the abscess has been laid open, it will be often found that a large indolently inflamed gland appears at the bottom. Between such gland and the opposed textures no union will generally exist, and nothing is more common than to be able to pass a probe around the circumference of the gland. Matter is apt to lodge in these intervals, and inflammation and burrowing to ensue, with the formation of sinuses.

Nothing can be more troublesome to cure than such buboes; and by far the shortest course is to destroy the gland by caustic, or to put the patient under chloroform, incise the gland, and detach it with the handle of the knife or fingers, subsequently stuffing the wound with lint.

As the last may appear a severe plan of treatment, it may be well to try first the effect of repeated applications of nitrate of silver or the red oxide of mercury, by which the gland tissue is gradually destroyed, and contraction of the walls of the abscess sometimes follows.

Sinuses, here as elsewhere, must be laid open; for it is very rarely that these heal by the injection of astringent and stimulating lotions. Of course, however, the effect of these can be tried before proceeding to the incisions.

When a sinus runs perpendicularly downwards—*i. e.*, at right angles to the surface of the body—it cannot be laid open. An enlarged and inflamed gland will be found occupying the base of the sinus, and preventing its healing. By applying caustic to this, and stuffing the part with lint, it may generally be made to heal from below. So soon as there is a healthy granulating foundation, the sinus will begin to fill up. If the process becomes chronic, it is a good plan to pass a narrow bistoury to the bottom, and incise the walls of the sinus, applying pressure afterwards.

During the whole treatment, the patient should live well, taking as much air and exercise as he well can, and steel with tonics are generally indicated.

Local treatment of primary specific inflammation.—Regarding the primary adhesive inflammation as the portal through which the syphilitic disease enters a patient's constitution, the first question which naturally arises is, whether the poison may not be destroyed in embryo by caustic, while the disease is as yet local. The writings of many authors would lead to the belief that this might generally be accomplished, provided the patients came sufficiently early under observation. If the results of the application of the syphilitic poison were always immediately developed, and if the affection produced by it always ran a definite course, terminating as has been so often erroneously described in the specific pustule, nothing would appear more easy and simple than at once to destroy the disease. But it has already been shown (section iii.) that the description of the development of the suppurating sore does not apply to the infecting chancre; a period of incubation may here exist, lasting over days or weeks, and during this time there is no means of knowing what part will ultimately be proved to have received the poison. There is, therefore, in such a case, no possible means of judging where the caustic should be applied. At the end of this period, if the caustic be applied immediately the disease appears, it will not prevent its progress. The poison has lain dormant for a certain period, and has been imbibed by the surrounding tissues. The destruction of a small portion of these will not prevent the development of the morbid action of the remainder. In cases, however, where the results of syphilitic inoculation have appeared shortly after the application of the poison, the application of caustic furnishes a most efficient remedy against the further progress of the disease. The destruction of the tissue involves that of the poison which it contains. The experience of Sigmund of Vienna coincides with that of Ricord and other observers in establishing the fact, that if a part to which the syphilitic virus has been applied be destroyed by caustic within the first four days, no constitutional symptoms will follow; but inasmuch as the characters of the infecting sore very seldom declare themselves within this period, the remedy is one which cannot be said to be applicable to such sores.

The indurated chancre does not ordinarily produce much inconvenience, and were it not for its consequences, would require little attention. It is true, indeed, that an indurated sore will sometimes become intractable, and be followed by a troublesome ulceration; but this occurs in general only where the patient's system has been infected with the poison, and where the local symptoms are a part of the secondary disease.

The object of treatment in the primary specific adhesive inflammation is to get rid of the induration; so long as this remains, the patient is never safe from its consequences.

Excision of an indurated part has sometimes been practised; but, as in the case of the application of caustic when the disease has declared itself, the remedy is too late. The cut edges of the wound always take on the specific action, but this induration is probably not so persistent as that of the part originally infected; so that, although there can be no reasonable expectation of cutting short the disease by this mode of treatment, the patients ultimately appear to do better than where the original adhesive inflammation is left to run its course.

The best local application is some form of mercury. The common mercurial ointment may be applied, spread upon lint; or calomel, combined with mucilage and lime-water, may be used in the form of a lotion; or the surface of the part may be dusted with calomel-powder. Solutions of perchloride of mercury are also

frequently used, in the proportion of one grain to an ounce of water. The subbromide and perbromide of mercury may also be used either externally or internally, in the same quantities as the subchloride or perchloride.

In cases where it is an object to cure a primary ulceration quickly, perhaps the best application is calomel fumigation locally applied. As this remedy is efficacious in various other forms of syphilitic disease, its mode of application will be described separately.

[The general treatment of the patient affected with sloughing or phagedænic chancroids is a point of chief importance to which the author calls but little attention. In addition to the ferruginous tonics, air, and exercise, mentioned above, the nutritive processes should be reinforced by all the methods recognized as valuable in modern medicine. Local treatment of these and other unhealthy sores by continuous submersion in the hot-water bath, lately revived by Cooper,[1] has accomplished brilliant and desirable results. Finely powdered iodoform sprinkled over the surface is at present accorded a deserved favor, not only as a substitute for cauterization where the latter is impracticable or forbidden, but also as a convenient dressing after the destruction of the sore. The chief objection to its use lies in the fact of its peculiarly pungent and slightly disagreeable odor, which may be corrected wholly by its precipitation from ethereal solution, and, in part, by its admixture with powdered talc or other similar substance. It produces, immediately after its application, a slight sensation of tingling, which is succeeded by an anæsthetic effect, under which cicatrization progresses. Operations for phimosis and paraphimosis are frequently demanded by the occurrence of these complications, care being then taken to prevent inoculation of the wounds inflicted by the surgeon with the virus of the sores. Occasionally, however, inaccessible sub-preputial chancroids may be treated with satisfactory success by injections passed into the preputial sac by the aid of the flat-nozzled syringe devised by Taylor, of New York.

It should not be forgotten that local medication of these sores by grease-compounded unguents, inclusive of those containing mercury, tends to prolong the period of their virulence.

The bubo accompanying chancroid ulceration may occasionally be relieved, before fluctuation is evident, by the method advocated by Auspitz. The gland is forcibly squeezed towards the skin with the fingers, punctured rather than cut, with a sharp narrow blade, and a blunt-pointed probe then passed deeply into the gland and moved about so as to tear the tissue in the focus of the inflammatory process. Carbolized lint is then applied with moderate pressure, and, in the course of forty-eight hours, the puncture has closed and the swollen gland been reduced to a small indurated lump.

Treatment of the primary syphilitic ulcer, by complete excision of the neoplasm, has been recently revived by Auspitz, Sigmund, and others, without, however, establishing conclusively the utility of the plan. These authors fail to distinguish between infecting and non-infecting primary lesions, and hence cloud with doubt the character of the sores whose excision is not followed by constitutional syphilis. The initial sclerosis yields readily to the action of mercury when administered by the mouth, but it is better to defer such internal treatment, in all cases where practicable, till the close of the second incubative period is demonstrated by the presence of an exanthem and other symptoms. As a local application mercurial ointment should be limited to chancres of the skin proper. Cleanliness is of prime importance, and the simpler lotions and dry powders named by the author, in connection with the topical employment of lint or "antiseptic cotton," will generally suffice to insure, or at least not hinder, the process of cicatrization.]

[1] Lancet, May 24, 1879, p. 731.

VII. Syphilitic Inoculation Modified by Previous Disease: Twofold Inoculation.

As the effects of vaccine inoculation may wear themselves out, so that a patient after the lapse of a certain time may be re-vaccinated, so may the syphilitic poison after a time occasionally reproduce the genuine infecting chancre upon the same individual. But it continually happens that patients constitutionally syphilitic are exposed to fresh infection before the influence of the first disease has passed away. The inoculation may then succeed in a modified form. A pimple, a small tubercle, or an abortive pustule may result; but these may all want the characteristic symptoms of the originally infecting disease. These modified actions are also peculiar in not having the period of incubation, which is natural to the original infecting sore. They commonly appear shortly after exposure, and are likely to occur, generally in proportion to the irritating nature of the discharge, with which the poison is combined. Thus an indurated sore which does not furnish a secretion which would be inoculable upon a person who had already had syphilis,

might, if artificially irritated, become inoculable; or a secondary affection, which is not communicable under ordinary circumstances, may, when producing or combined with an irritating secretion, become communicable. Cases of this nature are continually presenting themselves in practice. The affections which result differ from those which constitute the ordinary forms of primary syphilitic infection, and they may safely be treated without mercury. The following cases illustrate this subject experimentally :—

Case 1.—H. C. came under my care in the Lock Hospital on February 2, 1854. She had a syphilitic eruption upon the skin, and several irritable sores upon the inner margins of the labia and perineum. The inguinal glands were enlarged and indurated.

Feb. 4th. Several spots were inoculated from angry-looking sores on the margin of the anus and labia.

6th. Several fresh inoculations were performed from other irritable sores.

11th. Each point inoculated had produced a kind of pustule. Fresh inoculations were made with the secretions of the original sores, and with that of the artificial inoculations.

13th. Upon each point last inoculated a vesicle had appeared.

14th. The secretion of each vesicle had become turbid.

16th. Fresh inoculations were performed from the sores, natural and artificial, which furnished the largest amount of secretion. Eighteen hours afterwards the inoculated spots were found to be slightly reddened.

18th. Forty-four hours after the last inoculations no result was perceptible. Several fresh spots were inoculated with the secretion of the sores near the anus, and with that of the sores artificially produced.

22d. The last inoculations had produced no effect. The inoculations of the 11th were forming small dry scabs. The eruption had now faded.

24th. Several spots were inoculated with as much secretion as could be obtained from any of the sores.

27th. The inoculations last made had produced no effect.

March 2d. The sores, natural and artificial, had all healed. The patient was discharged as cured, having been under treatment exactly four weeks, and having apparently during the last two weeks not been susceptible of any further inoculation by means of the secretion derived from her own sores.

It was at first difficult to say why, in this case, some of the inoculations were capable of being reproduced, and some not; why those last made were of a different character from the first; and why the results of all the inoculations disappeared in so short a time.

These questions appear to derive a solution from the following two cases, which show that although an infecting sore is not capable of being inoculated under ordinary circumstances, yet the same sore will, under a state of irritation, produce an inoculable secretion, and that the effects of the inoculation of that secretion will vary according to the amount of irritation present at the time the secretion is produced.

Case 2.—A lad was admitted into the Lock Hospital on July 29, 1858. He had had gonorrhœa six months previously, but otherwise had been free from any venereal affection until about a fortnight before his admission. He then had a superficial sore behind the corona glandis, which healed in a few days. Two or three days after the first appearance of this sore, a little pimple appeared on the outer skin of the prepuce. This, on July 26, presented all the appearances of a well-marked Hunterian chancre. It discharged from its surface a white turbid secretion. To a portion of this a drop of acetic acid was added, and it was examined by the microscope, and found to contain no pus globules.

July 27th. The secretion was inoculated in several points on the patient's thigh.

29th. This was the day the patient was admitted into the hospital. The secretion from the sore was again examined, and found to contain no pus.

31st. Several fresh inoculations were made. The sore continued to increase in size.

Aug. 3d. None of the inoculations had succeeded. The glands at the back of the neck were now enlarged, and the skin presented an incipient syphilitic eruption. A small blister was applied to the surface of the sore.

5th. A superficial slough had formed on the surface of the sore, which yielded in parts a puriform secretion. This was inoculated upon the thigh in several points.

7th. The sore now again secreted no pus. Fresh inoculations were performed.

10th. The sore was dressed twice yesterday with the savine ointment, and now yielded a copious secretion of pus. This purulent secretion was inoculated in several points on a different part of the thigh.

12th. The inoculations last made had succeeded. The sore still yielded a copious secretion of pus.

14th. The inoculations both of the 5th and 10th had now succeeded, but not those of the 7th. They presented the appearance of circular red patches, with some elevation and thickening of the cuticle. In one place there was the appearance of a vesicle, from which a serous fluid exuded. This fluid was again inoculated upon the patient's thigh. The original sore, which had been dressed with water, now again yielded no pus.

17th. The inoculation from the inoculation had succeeded. It presented the appearance of a red circular patch, with slight thickening of the skin, from which the cuticle was abraded. It had not in the least assumed the appearance of a pustule, nor was anything like pus secreted from its surface. A single pustule, surrounded by very little inflammation, had, however, formed in one of the points first inoculated.

19th. The inoculations appeared as separate red patches on the skin, which in these situations was slightly raised and thickened,

but no induration extended into its substance. The solitary pustule which appeared had dried up.

24th. One of the inoculations first made had a slight tendency to ulcerate; the others were desquamating and losing their color.

Case 3.—Bridget C., aged seventeen, was admitted into the Lock Hospital on August 26, 1858. She had suffered from a thick yellow discharge between two and three months. This was followed, in the course of as many weeks, by the appearance of two small places on the upper part of the left thigh. These, upon her admission, presented all the characters of well-marked primary indurated chancres in a state of progress. The surfaces of these sores were covered by a scanty tenacious secretion, in small quantity, which, upon microscopic examination, yielded no pus. This secretion was carefully inoculated upon the patient's thigh.

Aug. 28th. The inoculation was repeated. There was at this time no indication of the sores having any tendency to heal.

31st. No result from the inoculations. The two sores had now been dressed for two days with the savine ointment, and yielded an abundant secretion, distinctly purulent. The secretion from each sore was inoculated in several points close together in two separate places in the thigh.

Sept. 2d. The inoculations last made have produced the appearance of small incipient pustules in both situations. The secretion from one of these was inoculated in two or three points on the thigh lower down.

4th. The inoculations from the inoculations had apparently succeeded. One of the inoculations of August 31 had produced a small pustule. The others had produced only vesicles. The skin over one of these was broken.

9th. The inoculations from the inoculations, performed on September 2, have dried up. The inoculations first in order of August 31 had entirely lost their puriform character. They now appeared as circular patches, and yielded a serous secretion, mixed with epithelial scales. The original chancres were now in process of healing.

11th. The inoculations first in order were desquamating, and of a light-red color. The inoculations from the inoculations appeared as small red pimples, which were gradually losing their color.

17th. The original chancres were cicatrized. The inoculations were fading and desquamating.

23d. The inoculations from the inoculations were still visible, and appeared as shining scales of discolored epithelium.

25th. A few faint secondary spots appeared on the body. The original sores were quite healed, leaving slight induration. The corresponding glands in the groin were still enlarged and hard.

Oct. 4th. This patient now left the hospital, but again presented herself on the 8th. The inoculations appeared as brown spots, the color of which gradually faded into that of the surrounding skin.

It is quite possible that the persistence of the inoculations, and their peculiar color in the two last-recited cases, may have depended upon the syphilitic diathesis of the patients. But this in no way militates against the fact that inoculations succeeded at one time, while they failed at another, under precisely the same conditions of the general system.

In Case 1 the inoculations succeeded so long only as the sores furnishing the secretion maintained their irritable character, and failed as soon as this irritability subsided.

In Cases 2 and 3, the sore, the natural secretion of which could not be inoculated with the lancet upon the patient, furnished an inoculable secretion when artificially irritated.

In all the inoculations above recorded, the effects appear to have been in direct relation to the amount of irritation present, and generally in proportion to the puriform condition of the secretion inoculated. It might be supposed that in the first case the sores ceased to be inoculable because they were in a healing condition, but this would not account for the fact that the inoculations produced from them, ceased to afford an inoculable secretion within four or five days of their first appearance. The inoculation, then, of the secretion of a sore affected with specific adhesive inflammation may take place; but is not easily performed, when once the patient's system has been affected with syphilis. When successful, the results are very different from those which follow the inoculation of the secretion upon patients not previously syphilitic, or the inoculation of the secretion from naturally suppurating sores. In the latter case each puncture produces a pustule, which by repeated inoculation will produce its like a great number of times. The inoculation of the secretion from infecting sores upon patients previously syphilitic, as a rule fails, or succeeds only under circumstances of accidental irritation. It then can be repeated a very limited number of times; and the results obtained, even by a number of punctures in one situation, are comparatively of a trifling description.

There is one circumstance which requires to be noted in connection with this modified form of inoculation, and which, unless duly understood, might sometimes lead to an erroneous diagnosis. It will occasionally happen that a patient, previously syphilitic, will become inoculated again in a modified form, and upon the point thus inoculated a secondary effusion of plastic material, dependent upon the first infection, may occur. The irritation produced by the modified inoculation will

then become surrounded by a certain amount of induration, and this affection may then easily be mistaken for a primary infecting ulcer. Again, it will sometimes happen that a secondary induration upon the prepuce (the consequence of a previous infection) will become abraded, or will ulcerate spontaneously. The appearances then produced are very similar to those which accompany the primary infection, and they are here particularly noted in order that these different diseases may not be mistaken for each other.[1]

Case.—M. H., aged eighteen, had previously suffered from syphilis. She was inoculated with the secretion of an infecting sore which had previously been irritated by the application of the savine ointment, and in another place she was inoculated with the secretion from a syphilitic ecthymatous pustule in its natural condition. On the third day the first inoculation appeared to have taken; but on the eighth the appearances had faded. At the expiration of five weeks there was a slight, accurately defined induration around the second inoculation.

Case.—A woman, who, from her previous mode of life, had every chance of becoming syphilitic, was inoculated with the secretion from an infecting sore. A pimple followed the inoculation. At the expiration of a month the pimple was still there, and was surrounded by a faint-brown, copper-colored eruption. These spots occupied a diameter of about six inches, and faded ultimately of their own accord. No other local or constitutional affection appeared as the result of the inoculation.

A modified syphilitic eruption, confined to the neighborhood of a second inoculation on a patient previously syphilitic, is not uncommon. It is not unfrequently observed in women of the lower class. A syphilitic affection, presenting the distinctive characters of the primary infecting sore, more or less modified, will appear perhaps on some portion of the skin, and after a comparatively short interval an eruption will follow, confined to within a few inches of the modified inoculation. Any general mercurial influence is scarcely required for such affections.

Plate V. fig. 11, represents an indurated sore which was made to suppurate artificially. Fig. 12 represents the inoculation from that sore, and fig. 12A the inoculation second in order.

The drawings were made on the eighth and ninth days respectively, and show the inoculations already fading away. Sometimes, however, especially after the lapse of time, inoculations on a patient previously syphilitic may run much the same course, and be followed by the same symptoms as if the patient had not previously had syphilis.

A gentleman had a syphilitic sore, which was followed by a general eruption on the skin. He then passed two years in the West Indies. After this he returned home, with the faint brown stains of the eruption still visible. In London he contracted fresh disease. Two well-formed indurated and circular chancres presented themselves on the glans penis. In a few weeks these were followed by a well-marked crop of syphilitic lepra, of a bright copper color, and quite distinct in appearance from the brown stains of the first eruption.

When a second infection occurs in this way after the lapse of some years, it is not in general attended with the same amount of enlargement of the inguinal glands, but something like the usual period of incubation exists between the application of the poison and the appearance of the symptoms. There can now be no doubt that a patient's constitution may so far become free from the consequences of a syphilitic infection that, in exceptional cases, he may become infected a second time, and that the fresh infection may then run its natural course much in the same way as if no previous disease had existed; such cases, however, are very rare. In general, if a second infection occurs, it is in a modified form; and if it should be followed by any constitutional symptoms, these present themselves also in a very mild manner.

In patients whose constitutions are under the influence of syphilis the period of incubation of a second infection is as a rule comparatively short.

Case.—A medical student became diseased for the first time in the year 1856. As soon as the sore appeared, and before it had become indurated, he inoculated some of the secretion on his own thigh. I saw him three or four days afterwards. There were then signs of irritation on the inoculated spot. This spot soon became converted into a small, hard, button-shaped sore, and then accurately resembled that from which the inoculated secretion had been taken. A small quantity of white lymph was at first visible in the inoculation, but both sores subsequently remained as small, hard, circular indurations, and furnished scarcely any secretion from their surfaces.

It would therefore appear—

1. That after a first infection, and before the induration has appeared, a patient is susceptible of being inoculated again with the same disease, from the same or from another source.

2. That after the induration has appeared, he is no longer capable of being inoculated with the infecting variety of the disease, except in cases where the in-

[1] The inoculation of ordinary pus will, in certain states of a patient's constitution, be followed by a well-developed pustule.

oculated matter is derived from a part which has been subject to considerable irritation, and that even then the inoculations produce comparatively little effect, and are not followed by any additional constitutional symptoms.

3. That after a certain time the effects of the first infection may, in a great measure, subside, and that then a modified form of inoculation may take place, which may be followed by fresh constitutional disease; but that this also, when it does occur, appears usually in a very modified form.

4. That this second infection is not likely to be accompanied by enlargement of the inguinal glands.

5. That the period of incubation of the second infection varies in inverse proportion to the degree in which the constitution is at the time influenced by previous disease.

The various forms which have now been described in which syphilitic inoculation may be modified, often render the diagnosis of a case in its early stages very difficult. If a case be seen once only, some accidental complication is particularly liable to lead to an erroneous opinion; but if the case be watched for a short time, there will seldom be any doubt as to its real nature.

Nature is, as I believe, always true to herself, and if interrogated fairly, she will furnish a faithful answer. But this answer is given at her own time and in her own way. If the surgeon demands an immediate response the first time he sees a syphilitic sore, he may be disappointed; but if he will carefully watch the course of the disease, he may with confidence rely upon the information he receives. If a persistent form of suppuration be established after inoculation, natural or artificial, *that* disease is of the non-infecting kind, as far as the patient's constitution is concerned. If the adhesive form of inflammation be established, although after the lapse of some weeks, secondary symptoms will follow. If both kinds of inflammation be present, then the patient has received a twofold inoculation, and each disease will run its course, modified, perhaps, by, but in spite of, the other. (Plate III. fig. 7.)

Twofold inoculation may occur either in the same or in different parts, at the same or at different times. When it occurs in the same part and at the same time, the results of the inoculation of the secretion from the suppurating sore will first develop themselves, and, subsequently, the results of the inoculation of the secretion from the infecting sore. This depends upon the different period of incubation which naturally belongs respectively to each kind of disease.

The cases which have led to the greatest confusion in practice are those in which the inoculation of the secretion from a suppurating sore has followed, after the lapse of three or four weeks on the same spot, the inoculation from an infecting sore. We have, then, the results of two kinds of action, and their respective products in close proximity. The suppurative inflammation does not, then, *prevent* the infection of the patient's constitution; the adhesive inflammation does not prevent the appearance of the "specific pustule." The means of diagnosis, which would refer these mixed sores either to the infecting or to the suppurating class exclusively, are therefore absent.

Although, in such cases, it may be very difficult to form a correct diagnosis at once, yet by watching the course of the symptoms this may be done with much accuracy.

VIII. Transmission of Secondary Syphilis.

The contagious character of secondary syphilitic affections was generally admitted before the time of Hunter. In the experiments which he made he was led to the conclusion that the products of constitutional syphilis were "not capable of acting in some respects on the same body or same state of constitution as that matter does which is produced from a (primary) chancre." He says that the secretion from a chancre generally when absorbed produces a bubo, but that we never find a bubo arising from a secondary syphilitic sore. When there is a venereal ulcer in the throat, no buboes appear in the glands of the neck. Venereal sores on the arms, or even suppurating nodes on the ulna, do not as a rule produce swelling of the axillary glands, although these will very certainly be affected if syphilitic matter from a primary chancre be inoculated on the skin of the arm. Again, when syphilitic blotches or nodes form on the legs and thighs, the specific affection of the glands in the groin, which accompanies primary infection, does not occur.

These considerations so far biassed Hunter's mind, that he came to the conclusion that the secretions from the secondary syphilitic affections were not inoculable. He mentions, however, that it was asserted in his day that ulcers in the mouths of children, derived from constitutional and hereditary disease, produced the same disease upon the nipples of women who suckled them. That is, the children were contaminated either by their mothers or fathers; the child received the disease by hereditary descent; and the nurse was infected by the child.

"If," Hunter observes, "it were possible to contaminate once in this way, it would be possible to contaminate for ever. How far the observations upon which the before-mentioned opinion is founded have been made with sufficient accuracy I know not."

As has been already pointed out, Hunter committed the grave error, in which he was eagerly followed by a host of subsequent writers, of supposing, because the syphilitic poison was not inoculable as a rule upon the person who produced it, that, therefore, it was not inoculable upon a person who had not previously had the disease.

Experiments and observations have now been made with sufficient accuracy, and repeated a sufficient number of times, to show that the circumstances contemplated by Hunter actually do exist, and that syphilis may be communicated in this way, and that it may be so communicated from one patient to another an unlimited number of times, so long as the poison is brought in contact with a person not previously infected. With the increased light which modern investigations have shed upon this subject, it is not uninteresting to contemplate some of Hunter's own cases.

A child was supposed to have infected its nurse with syphilis. The parents had been married about twelve years. The mother fell into a weakly state of health, and miscarried of her third child at the end of five months. The fourth child came at seven months, but was puny, weak, and had hardly any cuticle when born. It was immediately after birth attacked with a violent disorder of the bowels, so as to purge blood. It died in a few days, and was opened by Hunter. The whole skin was almost one excoriated surface. The intestines were much inflamed and thickened.

With her fifth child, from great care, this patient went eight months, and it was hoped she might go her full time, and also that this child might be more healthy than the former. When she was delivered the child was very thin, but free from any visible complaint.

Some days after birth, it became blistered in a vast number of places on its body. These blisters were filled with a kind of matter which broke and discharged a thinnish pus. The inside of the mouth was in the same condition. About three weeks after its birth it died.

Some weeks after the death of the child, the nurse's nipple, and the ring round the nipple, inflamed, and sores or ulcers were formed with a circumscribed base. They were poulticed, but without benefit. She also complained of a sore throat, but the sensation she complained of was so low in the throat that nothing diseased could be seen. A swelling took place in the glands of the armpit, but they did not suppurate. She applied to a physician, and from the account she gave he pronounced her disease to be venereal, and that she had given suck to a *foul* child; and ordered ten boxes of mercurial ointment to be rubbed in on her legs and thighs, eight of which had been used when Hunter saw her, and then her mouth was become extremely sore.

These circumstances came to the ears of the family, and an alarm took place. The husband went from surgeon to surgeon, and from physician to physician, to know if it was possible for him to have the disease for fourteen years, and never to have perceived a single symptom of it in all that time; or if it was possible he could get children with the disease now, when the two first were healthy. He also wanted to know if it was possible for his wife to have caught the disease from him under such circumstances; and also, if she could breed children with this disease, although she herself never had a single symptom of it.

Hunter ordered hemlock, but that appeared to have no effect. While this was going on, eruptions broke out on the skin. The skin of the hands and fingers peeled off, the nails of both fingers and toes separated, and sores formed about their roots, which were all supposed to be venereal. She looked dejected and sallow. She was desired to go into an hospital, which she did. As soon as she got into a warm bed, and had good wholesome food, she began to mend, and in about five or six weeks she had got fat and almost well, the sore only about the root of the nail of the great toe had not healed; but that appeared now to be owing to the root of the nail being detached, therefore acting as an extraneous body. She came out of the hospital before this toe had got well, and by returning to her old poor mode of living the soreness in the mouth returned; however, she mended in the end without the use of more mercury.

Had not Hunter been deceived by his own experiments, and come to the conclusion that constitutional disease could not be communicated by contact, such instances as he has himself related must have led him to a different conclusion.

The following cases are among those which he has recorded, in which the disease was supposed to have been produced by the transplantation of teeth:—

A young lady had a tooth transplanted, and the tooth fastened extremely well. It continued firm for about a *month*, when the gum began to ulcerate, leaving the tooth and socket bare. The ulcer continued, and blotches appeared upon the skin, and ulcers also in the throat. The disease was treated as venereal, and the symptoms disappeared, but they recurred several times after very severe courses of mercury. She at last got well.

A gentleman had a tooth transplanted, and the tooth remained without giving the least disturbance for about a *month*. The edge of

the gum then began to ulcerate, and the ulceration went on until the tooth dropped out. Some time afterwards, spots appeared almost everywhere on the skin. He was put under a course of mercury, and all disease disappeared. Some time after, the same appearances returned, with the addition of swelling in the bones of the metacarpus. He was now put under another course of mercury more severe than the former, and in the usual time all the symptoms again disappeared. Several months after, the same eruptions came out again, but not in so great a degree as before, and without any other attendant symptoms. He a third time took mercury, but it was only ten grains of corrosive sublimate in the whole, and he got quite well. The time between his first taking mercury and his being cured was a space of three years.

In the Medical Transactions of the College of Physicians of London, published in the year 1785, Dr. William Watson, at that time the vice-president of the Royal Society, gives an account of the case of a young unmarried lady, about twenty-one years of age, who had a tooth transplanted into the socket of one of the incisors of the upper jaw. The new tooth fastened exceedingly well. It remained firm for a month, when her mouth became very painful. The gum became ulcerated, and part of the alveolar process was left bare. Before another month the ulceration occupied the whole space under the upper lip, between the teeth and nose. It extended likewise to the cheeks and throat. Blotches then appeared on her face, neck, and various parts of the body; several of these became ulcerated painful sores. After trying a variety of tonic medicines without benefit, two grains of calomel were ordered once or twice a day. She took about fourteen pills when she was obliged to discontinue the use of the calomel, on account of the griping and purging. During the time that she was taking the pills the ulcerations of her mouth and cheeks did not spread, but were less painful, and of a milder appearance. The blotches on her face and body grew paler, and such of them as had ulcerated healed apace, and no new ones appeared. The mercurial inunction was now tried, but in ten or twelve days the griping and purging returned, and the ointment was discontinued.

The good effects of the mercury were, however, Dr. Watson observes, very apparent. The blotches all disappeared; the ulcerations in her face and body completely healed, and those of the mouth nearly so. A portion of the alveolar process subsequently exfoliated, and ultimately the patient died.

Dr. Watson remarks, that the progress of this disease not being impeded by the most powerful antiseptics, and its giving way to mercurials, even in small doses, cannot but suggest that the disease was truly venereal.

At the time that such cases as the above were recorded, had not the idea taken possession of some men's mind that absorption of syphilitic poison under the circumstances was impossible, the diseases described would doubtless have been assigned to their right cause.

In some of the cases care was taken to wipe the surface of the tooth before it was transplanted, and it was thought that by so doing, every chance of inoculation would be prevented, but a brief reflection on some of Hunter's own experiments is sufficient to show how futile such a notion is. In the experiments which Hunter performed of transplanting teeth and other parts from one animal to another, it was clearly proved that each part of a living being has its independent vitality, which it can maintain for a certain time independent of the rest. In the Museum of the College of Surgeons there is now a tooth which Hunter transplanted into the comb of a cock. The tooth grew in its new situation, and when the cock died, Hunter injected the tooth through the bloodvessels of the cock. During the time that the tooth was withdrawn from its natural socket, and before it had acquired any fresh connection in its new bed, it maintained its own vitality. Subsequently its bloodvessels communicated freely with those of the cock, and their contents passed into each other.

Now it has clearly been shown that the blood of an infected person may, when inoculated, communicate syphilis. If, then, the tooth of an infected person be transplanted into the mouth of a person who never before has had the disease, the minute quantity of blood which it contains may be sufficient to infect the healthy person; and it is quite clear that simply wiping the outside of the tooth would not prevent such an occurrence.

It is not, however, only the blood of an infected person, or the secretion of what are usually called secondary symptoms, which may become the means of communicating syphilis from a person constitutionally affected to one who has not previously had the disease. There is reason to believe that the secretion of any of the mucous membranes of a syphilitic patient when in a state of increased activity or of inflammation may produce the same effect.

Dr. Marston, who has lately contributed a very valuable paper to the Medico-Chirurgical Transactions, has, by quite an original and independent series of observations, arrived at very much the same conclusions as myself upon this subject; and his cases are the more valuable, since his opportunities as an army surgeon of ascertaining the exact condition of his patients during their illness, and of observing them afterwards, are much greater than can ordinarily occur in private practice.

The following are among Dr. Marston's cases :—

Two men were admitted into hospital with gonorrhœa, Br. A. and Gr. S. The men came to hospital within forty-eight hours of each other, and were placed in contiguous beds. Gr. S. went with the police, and pointed out the source of his contagion. Br. A. went upon the same errand to the same house, and found the woman already removed. Gr. S. told me that, to their mutual surprise, they discovered that it was the same woman in each case. Both suffered from all the symptoms of gonorrhœa, and there was no suspicion to the contrary. Br. A. had suffered from syphilis before, Gr. S. never. After remaining in hospital a long time, Br. A. was discharged cured, and no further symptoms, so far as I could trace, appeared in his case. Gr. S.'s recovery was delayed from gleet and irritable bladder, for which instruments (Nos. 10 and 12) were used. They passed without difficulty, local tenderness, or hemorrhage. After appearing anæmic and in ill-health, Gr. S. had sore throat (ulcerated tonsils) and a guttural voice; subsequently papules appeared on the inside of the lips and the buccal membrane, coincidently with psoriasis palmaris and "nocturnal rheumatism." The inguinal glands were slightly enlarged symmetrically. For these symptoms he took iodides of mercury and potassium, with mercurial vapor bath, by which means, after many relapses, he was cured. The case was shown to some surgeons, who, of course, suggested a concealed chancre ("chancre larvé" of Ricord). I passed sounds, and tried to discover a localized induration, without avail. If anything, perhaps the canal was firmer and more swollen to the touch than usual. Some urethral discharge was inoculated in the skin of thigh (at the time it was gleety and apparently prostatic secretion), without any effect.

The woman in this case, I learnt from the civil surgeon, had a vaginal discharge, but no primary ulcer that he could find. She was, however, suffering from acne of the face and a cutaneous syphilide.

Gr. C, five or six days after connection, had urethral discharge, and was admitted as suffering under "gonorrhœa" by another medical officer. After the use of nitrate of silver injections and salines, as abortive treatment, he rapidly improved, but a slight gleet remained, for which the penis was blistered. This urethral discharge afterwards augmented in amount, and became most copious and purulent, and symptoms of cystitis set in. After having been in hospital eight weeks, he came under my care. Upon the dorsum of the penis were two large, oval, indolent, indurated, raised lumps. To me they appeared chancres. The glands of both inguinal regions were passively enlarged. In answer to my questions, and without any suggestion whatever on my part as to their nature, he said, "One has existed about forty-five and the other about forty-six days, as near as I can tell. They gradually became and remained as you now see them, and they came, I think, from the discharge getting in contact with two sore places from which the skin had been removed after blistering." In seventeen days both healed under the influence of mercury. I learn that a papular syphilide has since appeared upon the trunk. By a later report it appears that this man has again passed under treatment for marked anæmia, and ecthymatous sores upon the extremities.

Numerous cases similar to those of Dr. Marston have occurred under my own observation.

A surgeon in much practice in Tyburnia brought a young gentleman, who was supposed to have gonorrhœa only, for my opinion. There was a discharge from the urethra, but in addition there was a small circumscribed induration on one side at the junction of the glans with the prepuce. This was not accompanied by any ulceration, and might easily have escaped detection. There was in my mind no doubt as to the nature of the case, and I at once told the surgeon and the patient that secondary symptoms would follow. My prediction was but too surely verified.

It is by no means always easy to say whence the secretion is derived which contains the infecting matter. I have lately had under my care three medical men, each of whom had become infected in their hands during their attendance upon midwifery cases. In one of these instances craniotomy had been performed, and in attempting to extract the child the surgeon had his finger between the bones of the fœtal head. A pain then occurred, and pressed the bones violently against the surgeon's finger; an abrasion was the consequence. At the expiration of four weeks, a phagedænic-looking sore, surrounded by induration, appeared on the finger at the part corresponding to that which had been injured by the fœtal bones. This was followed by secondary symptoms, with extreme depression. For several years this gentleman was unable to attend to his business; but ultimately his health was entirely restored by a course of calomel baths.

In a second instance an indurated sore formed on the finger of a medical man, and his health was entirely broken down by the symptoms which followed. This case was complicated by the occurrence of secondary abscesses.

In the third case the surgeon would scarcely believe that the small irritable indurated spot which had formed on the side of his forefinger could have been the original cause of his failing health. The subsequent history of the case, however, fully revealed the real nature of the disease. The drawing (Plate V. fig. 13) represents an indurated primary tubercle on the hand of another medical man, which was but too surely followed by secondary symptoms.

Susan B., æt. 66, presented herself at King's College Hospital on October 24, 1853, with a scaly, copper-colored eruption raised above the surface of the skin, and having in some parts a tubercular appearance. She had also a well-defined and extensive indurated

sore on the lip. She stated that she never had any venereal affection, and had given birth to twelve healthy children.

Eighteen months before applying at the hospital she had noticed a pimple on the inside of the upper lip, which contained a little clear fluid. This broke, and a small sore formed, which, however, again healed in about a month, leaving a circumscribed induration. Three weeks ago the sore again broke out, and gradually extended until the date of her application at the hospital. An eruption made its appearance between three and four months from the first commencement of the pimple on the lip, and this had continued to recur at intervals ever since.

This old lady had taken her granddaughter to nurse, and having become exceedingly fond of it, was in the habit of constantly kissing it. Her son, she knew, had suffered from some venereal disease five months previous to the birth of the child; her daughter-in-law had died a few days after her confinement, and had not suckled her infant, which was consequently brought up by hand. When the child was ten weeks old, some sores appeared on its tongue and lips. These were followed, a week afterwards, by an eruption on the nates, which was still visible when the grandmother applied at the hospital, and was clearly of a syphilitic nature. This woman might have, and probably often did, kiss her son with perfect impunity, but the syphilitic poison appears to have acquired increased activity with the new life of the child, and with that increased activity to have become more readily communicable by contact.

The wife of a missionary applied to me with her husband, on January 1, 1861. She was the mother of a healthy family, and until recently had enjoyed good health. She had kept a kind of home for destitute girls, and to one of these girls, who was subsequently known to have been a patient of the Lock Hospital, was entrusted the care of this person's baby. After the lapse of a certain time the baby had a well-marked syphilitic eruption on the body and nates, the mother remaining in the mean time quite healthy. Four months after the affection showed itself on the baby, the mother had characteristic symptoms of secondary disease. I had an opportunity of tracing the course of the disease both in the child and in the mother; but, although every effort was made, I could never discover how it was that the child first received the disease, or by what means it was communicated to the mother. But the whole of the circumstances left no doubt whatever on the minds of any who witnessed the case that the disease had been given, by the girl who was taken into the missionary's family, to the baby, and that it was communicated by the child to its mother—an interval of four months having occurred between the first appearance of the symptoms in the child and in the mother.

One of the most interesting cases proving the inoculability of the secretion from a syphilitic patient, is one that occurred to Hunter himself, and which from being misinterpreted led many subsequent writers to doubt its accuracy. It, however, shows clearly enough that the irritated and inflamed mucous membrane of the urethra may furnish at the same time a secretion resembling that of a simple gonorrhœa, and also the poison which will give rise to an infecting chancre. Hunter inoculated himself on a Friday with matter from a patient supposed to be suffering from gonorrhœa. On the Sunday following there was a sense of itching which continued until the Tuesday. The inoculated part now appeared as a speck, was red and *thickened*. By the Tuesday following the speck had increased and discharged some matter. Caustic was applied and the sore healed, but four months afterwards it broke out again. It healed and opened again several times. A swelling took place in the right groin. This was followed by an ulcer on the tonsil and copper-colored blotches on the skin. The disease recurred more than once on the tonsil and on the skin, and was ultimately cured by mercury at the expiration of three years.

The same disease which Hunter conveyed to himself in the secretion from the inflamed mucous membrane of the urethra, may readily be communicated by the secretion from the diseased mucous membrane of the mouth in syphilitic patients.

The communication of the infection from one adult to another by the same means is not very uncommon.

A young woman had an eruption which was supposed to be syphilitic. Upon being questioned upon the subject she indignantly denied the possibility of such being the case. When I saw the eruption, and the accompanying sore throat, I had no doubt whatever as to its specific nature. I found on the tongue a raised, circular, hard lump, and the submaxillary lymphatic glands were in a state of chronic induration. This patient submitted to an examination. There was no enlargement of the glands in the groin, and the hymen was perfect. Upon inquiry it was ascertained that this patient was in the habit of using the same spoons as another servant who was known to have a syphilitic affection of the mouth. The mode of entrance of the syphilitic poison in this case was indicated by the persistent induration on the tongue, and by the corresponding chronic multiple enlargement of the submaxillary lymphatic glands.

A young gentleman about to be married had a well-marked circular induration, superficially excoriated, on his tongue. The submaxillary lymphatic glands were in a state of chronic indolent enlargement. The patient maintained that his symptoms could not be syphilitic, but admitted, upon being closely questioned, that he might have caught the disease on his tongue from the lips of an infected person. The nature of the disease was fully proved by the appearance, in a short time, of a very well-marked general syphilitic eruption.

M. Rollet has recorded a very striking case in which the disease was transmitted by the

mouth from one individual to another, and from him to a third.

A. S. had primary syphilis in 1858, followed by a papular syphilitic eruption, and excoriations on the lips. This patient was a glass blower, and in his occupation passed the tube through which he blew to another workman who carried on the process.

This second workman had in October a hard lump the size of a cherry stone on the anterior surface of the right side of the lower lip. The corresponding lymphatic glands became specifically affected, and on December 10 he had ulceration of the throat.

The patient passed the tube in his turn, after he had done his part, to another workman (F. G.) who completed the process. This third workman in December had several ulcerations on his lips, and a mucous tubercle at the back of the throat, with pain in swallowing.

The following case was communicated to me by Dr. Marston, to whom I am much indebted for many valuable suggestions in reference to the present subject.

"A gentleman was suffering from symptoms of constitutional syphilis. Besides other symptoms, he had some fissures and epithelial ulcers upon the inside and angles of the lips. These were certainly not primary, but a part of the secondary symptoms under which he was suffering. He stated that he feared he might have infected a female, by labial contact. From the nature of her symptoms I inferred that his fears were well grounded. In due course of time this female suffered from constitutional syphilis, and was treated for such by some eminent professional men.

"The first symptom in her was an irritable-looking and indolent fissure upon the mucous membrane of the lower lip."

M. Rollet is of opinion that a gonorrhœa in a syphilitic patient will not communicate syphilis. In this opinion he is probably correct, inasmuch as we know that the products of other morbid poisons, when inoculated from a syphilitic patient, will produce only the specific disease in which they originated.

But the case is very different when a purulent discharge originates or is continued in a syphilitic patient, independent of any adventitious cause. This secretion may then, without any distinctly recognized form of secondary syphilis, communicate the specific morbid action in which it had its origin. The viscid muco-purulent discharge which flows from the neck of the uterus in a state of chronic inflammation, in a syphilitic patient, may, doubtless, communicate a discharge (not necessarily gonorrhœal) to a man, and that discharge may be the means of conveying syphilitic infection.

In the cases of this nature which have fallen under my own observation I have thought the discharge more viscid and tenacious than that of ordinary gonorrhœa, not accompanied by the same amount of ardor urinæ, and of shorter duration.

But it is evident that a twofold disease, each of a specific nature, viz., a real gonorrhœa and a genuine syphilitic infection, may in this way be conveyed. This point is well illustrated by the following case. On May 6, 1861, I received the following in a letter from a well-informed surgeon in a large practice :—

"Mr. —— came to me in the middle of February with acute gonorrhœa, which was relieved by ordinary treatment in about five weeks.

"Early in April, nearly six weeks after I had seen him, a sore appeared on the prepuce, which I thought was an excoriation produced by the gonorrhœal discharge. After a few local applications this healed, but after healing it became surrounded with an indurated circumference, which makes me suspect venereal mischief."

In due course this induration was followed by well-marked secondary symptoms.

The natural secretions of the body, when the structures producing them are in a healthy state, cannot, in my opinion, be the means of communicating syphilis to another person, although the patient from whom these secretions are derived be constitutionally syphilitic. The following case may illustrate this subject :—

A married woman was admitted into St. George's Hospital on October 5, 1864. After her last confinement (having been previously quite healthy), she took a child to nurse in addition to her own. The strange child proved syphilitic. The woman had an ulcer on the breast, represented in the accompanying drawing. This was followed by a well-marked syphilitic eruption. (See Plate VI. fig. 14.) This woman had taken the precaution to keep each child to one breast; and, although her own child was allowed to suck for six weeks after the eruption had appeared, yet it remained unaffected.

We have here the natural secretion going on in a syphilitic mother : the organ itself, which produced it, not being specifically affected. We have the constant contact of a diseased and healthy person, and the transmission of the secretion from one to the other, and yet no disease is imparted.

Few of the natural secretions of the human body have been accused of being the means of communicating syphilis. The saliva and the semen are perhaps, besides the milk, the only two which are supposed to be capable of transmitting the disease. There is no reason why these secretions in themselves should be more susceptible of the syphilitic poison

Fig. 14.
Chancre ou
Ulcère ...

Fig. 15.
Bubon ...

than any of the other natural secretions of the body. If the organs which secrete them are not specifically affected, we cannot see why they should be more likely to contain the syphilitic poison than the urine or the bile. Now, all these secretions, before they pass out of the body, have to pass over tracts of mucous membrane. These portions of mucous membrane are peculiarly liable to secondary syphilitic affections; and, if the secretions in question become mixed in their passage with the products of specific inflammation, we may readily understand how they may be the means of carrying the disease, although, by themselves, they may have no power of communicating it. The fitful and uncertain way in which syphilis is imparted by hereditary transmission from the father, and the very small number of cases in which it has been supposed to be transmitted by the saliva, seem to point rather to some accidental causes of contamination than to any inherent disease in the semen or in the saliva in syphilitic subjects. Such accidental causes at once present themselves to our minds when we contemplate the admixture of the diseased secretions of the mucous membranes with the proper secretions of the glands.

The conclusions to which I have arrived myself, and which I would submit for the consideration of others, are:—

1. That the infectious form of syphilis is communicated by the secretions from both primary and secondary syphilitic affections.

2. That the secretion of other specific diseases existing in syphilitic subjects (including the specific syphilitic pustule, and the sores which result from it) have no power of imparting constitutional syphilis.

3. That the natural secretions of glands in syphilitic subjects, when those glands are not themselves specifically diseased, have no power of imparting constitutional syphilis.

IX. Hereditary Transmission of Disease; Vaccino-Syphilitic Inoculation.

If it be true that a patient is generally liable to syphilitic infection once only in his lifetime, the question presents itself with much point, how far a person who has had syphilis by hereditary transmission is protected from any fresh attack of the same nature. Several cases have lately come under my notice in which the effects of hereditary syphilis have manifested themselves as the patients were approaching puberty; and it is more than probable that if the visible effects of the disease can remain so long in a patient's constitution, its more subtle and secret influences may continue to a much later period. It is a point of very grave moment to determine how far such an influence derived by hereditary descent may have the same effect in preventing the reinoculation of syphilitic matter, as it is well known that acquired syphilis has.

Whatever may have been the cause of the failure of the inoculation, where the products of secondary syphilitic affections have been artificially introduced into the system of those, who were said not previously to have had the disease, it is obvious that one link in the chain of evidence has hitherto been wanting in those cases.

In order to be of any real value in demonstrating the non-inoculability of secondary syphilis, it would be necessary to show that the patients upon whom the experiments were made were susceptible of *primary* syphilitic inoculation. If in any case it were found that a patient showed no syphilitic symptoms after being repeatedly inoculated with the secretions from secondary syphilitic affections, and if afterwards the inoculation of the secretion from a primary infecting sore gave rise in him to an infecting chancre, then we might say that such an experiment was of some value in proving the non-inoculability of secondary disease. But until the susceptibility of a patient's constitution to syphilitic infection from *any* source is thus demonstrated, the negative evidence derived from his not being susceptible to infection from any particular form of disease is of little moment.

Among those who habitually expose themselves to syphilitic infection, it occurs every now and then that an individual is found who never has had the infecting form of the disease; and the question naturally arises—Why has he not suffered in the same way as others who have been similarly exposed? The answer which would generally be given to such a question would probably be, that it depended upon some peculiarity in the person's constitution. But we are bound, if possible, to ascertain and determine, as far as may be, what that peculiarity of constitution is. If we say that a patient can have syphilis once only during his lifetime as a rule, and if we find that a certain number of children have hereditary syphilis, does it not appear probable that these children, when they grow up, would have some kind of immunity from further infection; or that, if the disease did appear again in them, it would be in a greatly modified form?

Modern researches in this branch of science bring us back to that which shrewd observers, without the advantages which we at present possess, had long ago noted.

In 1812, Dr. Ferguson came to the conclusion that syphilis had become so much mitigated in Portugal, by reason of general diffusion or other causes, that after running a mild course it exhausted itself, and ceased spontaneously. Dr. Ferguson further mentioned that he had reason to believe that at that time, in other countries, the disease had become modified in a similar way. He mentions that in certain German regiments, and in some districts of the Russian empire, the medical attendants had found that mercury was not necessary for the treatment of syphilis, and that in the patients to whom he referred, the disease from being allowed to run its course probably for ages, had become as weak as it was found to be in the Portuguese. All adventitious diseases, says Dr. Ferguson, that are not connate, endemic, nor sporadic, appear more or less to run this course of exhausting themselves while retained upon the same ground to which they have been transplanted; but let the field be changed, and fresh sources of development be presented, and they will instantly resume their primary powers, and taking a fresh departure of violence, repeat the almost forgotten inflictions of their original visitation. The powers which they thus acquire bear some resemblance to a phenomenon which is everywhere observable in the vegetable kingdom. The same species of seed may be sown upon the same ground until it shall so degenerate in point of vigor, as to become almost incapable of reproducing itself; but let it be changed to any other kind of soil, though even of far inferior quality, and it will immediately display new powers of life, and fructify and vegetate with its native strength.

Corresponding with this description appears to have been the effect of inoculation of the exhausted syphilitic virus of Portugal into the constitution of the British or other strangers. It was in some measure new, therefore unfriendly, and seems to have had the power of exciting new actions of more than ordinary violence.

The Portuguese, through apathy, and at a dreadful price levied on the generations that are passed, and never in all probability to be redeemed by their descendants, appear to have gained a great exemption from both syphilis and variola; but the price is too high for us ever to offer up our bodies to be the unresisting subjects of disease, the fatal consequences of which, though they might go far to extinguish one or two ills, would be felt in the deterioration of our race to the most distant ages.

The same facts, with regard to the modified form in which syphilis appears in some of the lower classes of the community, have been observed in our own country.

Mr. Rose, formerly surgeon to St. George's Hospital, found from experiments conducted at one time on a large scale in one of the regiments of the Guards, that he could treat syphilis when it appeared amongst the common soldiers by topical applications alone. It is true, that at the time Mr. Rose conducted his experiments, no clear distinction was drawn between those syphilitic affections which, if left to themselves, would infect the constitutions of the patients, and those which would not; and, therefore, a great many sores were, no doubt, said to be cured without mercury which, under no circumstances, would have been followed by secondary symptoms. It is exceedingly probable, however, that a certain proportion of the cases treated by Mr. Rose really depended upon the infecting variety of the disease; and as Mr. Rose found that he could deal with these cases without administering mercury, we can only conclude that the disease he was treating had appeared in some modified form, such as Dr. Ferguson had noticed in Portugal, and such as he states to have existed also in Germany and in Russia. As soon as Mr. Rose tried his plan of treating syphilis without mercury amongst the officers of the regiment in which his experiments had been made, the plan was found to be unsuccessful; and we have the authority of Sir Benjamin Brodie, who witnessed these experiments, for stating that, in private, Mr. Rose treated syphilis with mercury like other medical practitioners; and that in cases where he did not administer it, he was continually becoming involved in difficulties.

To what, then, is to be attributed this comparative immunity to the severer forms of acquired syphilis, and the modified form in which it has been occasionally noticed, not only in Portugal, in Germany, in Russia, but also in our own country? The answer to this important question arises out of the observations already made. That which Dr Ferguson observed in his day may be seen at present. A person who has had hereditary syphilis in his youth will either not contract the infecting form of syphilis in after life, or will have it in a modified form. An extensive observation of cases as they occur in public hospitals will at once show that syphilis, as it presents itself among those classes who are likely to have inherited the disease, is a different affection from that which is observed under other circumstances. The same law may be traced in the history of individual cases. Instances have come before me where patients, the offspring of parents supposed

to have been syphilitic, have shown some modified syphilitic symptoms for many years after they have grown up; and these patients have appeared insusceptible to any further infection. But it may be said that certain individuals, who have never shown any symptoms of either hereditary or acquired disease, are also apparently not capable of receiving the infecting form of syphilis, or, if infected, that they have the disease in so mild a form as not to require mercurial treatment. The explanation of the occurrence of even these cases is not difficult. An instance lately came under my notice, where a woman with the remains of what I believed to be a syphilitic eruption, had been impregnated ten times. Seven of the children had died, either from the premature confinement of the mother, or within a year or two after their birth; of the remaining children, two had eruptions which were treated with mercury, and one only never had had any symptom of hereditary disease. Shall we say, in this exceptional case, that because the visible symptoms of any hereditary affection were wanting, therefore something like the same diathesis was not communicated to her, as to the other children? Or are we quite sure that hereditary syphilis, like gout and certain other diseases, may not pass over some individuals, or even a generation (as far as its sensible effects are concerned), again to appear in some modified form in their descendants? It would obviously be wrong, in the case of any hereditary disease, to say, because the symptoms were absent in an individual, or in one generation, that therefore the diathesis had ceased; and we know not yet through how many generations the latent effects of hereditary syphilis may not produce *some* influence. A man advanced in years, whom I knew from seeing him in a London hospital, and who had formerly had a variety of venereal affections, had a grown-up family. One of his daughters had an eruption on the skin at about seventeen or eighteen years of age, which eruption was treated with sarsaparilla. One of the sons, although he had frequently exposed himself to contagion, never contracted the infecting form of syphilis. This son married, and had a family. After a time his wife had an eruption on the body which was supposed to be syphilitic, and yielded readily to antisyphilitic remedies. Last of all, the son himself had an eruption exactly resembling that of his wife. This I had an opportunity of seeing, and believe it to have been a mild and modified form of hereditary syphilis, which had then developed itself in a visible form for the first time. Had this son been one of Mr. Rose's patients, he no doubt would have been successfully treated without mercury; but it would be a grave mistake to suppose that syphilis in what has been called a virgin constitution can be treated in the same way.

Case.—A young woman had an eruption for the first time after the age of puberty. This I considered to be syphilitic. The origin of the syphilis could, however, in no way be traced, until one day I accidentally saw the mother; the eruption on the mother's arm and on the daughter's chest are represented in Plate VII. figs. 16 and 17.

Several cases have come before me during the last few years in which symptoms to all appearance syphilitic could only be explained by hereditary transmission. In some of these there was a distinct history of syphilis on the father's side.

Dr. Viennois, in his thesis presented to the Faculty of Medicine in Paris in the year 1860, and also in the Archives of Medicine for the same year, has collected together and given a detailed account of some cases in which an infecting syphilitic sore, or, more properly speaking, the specific adhesive inflammation, followed vaccination. Dr. Viennois has carefully excluded those cases in which a fresh set of symptoms followed vaccination in patients who had previously had hereditary or acquired syphilis, and has confined himself to cases in which the primary affections could be clearly verified, and their effects upon the constitutions of the patients satisfactorily traced. Dr. Viennois's investigations led him to the belief that, if the lymph from a vaccine vesicle be alone inoculated, the cow-pox alone will be produced; but that if, in addition to this, the blood of a person affected with constitutional syphilis be inoculated at the same time, then syphilis may also be communicated. The cow-pox would then appear first, as having a shorter period of incubation; and after a time the syphilitic tubercle (or primary specific inflammation) would make its appearance upon the inoculated part, and would in due course be followed by secondary symptoms. The cases which Dr. Viennois has collected are related with so many circumstantial details, that, if correctly reported, they cannot fail of themselves to establish the fact that the poison of syphilis and that of the cow-pox, may be communicated, and sometimes have been communicated, at the same time.

During the period of doubt and suspense which followed Dr. Viennois's publications, two most remarkable circumstances took place. One of these was an artificial inoculation performed at the Hôtel Dieu; and the other the transmission of a disease, both by artificial inoculation and by natural means, to a large number of children, and to several adults, at Rivalta in Piedmont. These cir-

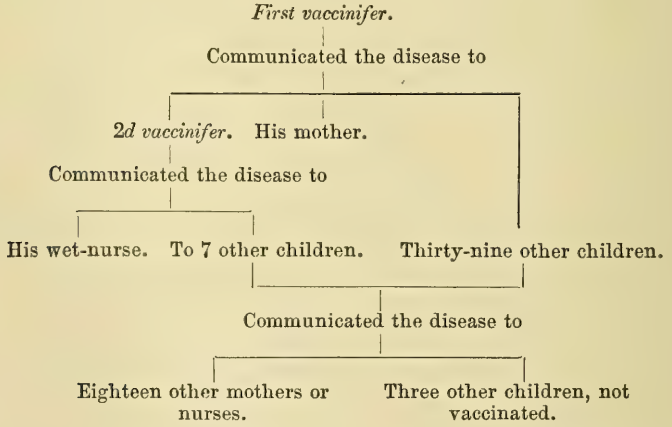
cumstances have occurred at the exact time in the history of syphilitic inoculation best calculated to dissipate the doubts which still hung over so many minds, and the symptoms which they represent will, I believe, if fairly interpreted, satisfy every unprejudiced inquirer. The first of these remarkable facts occurred in a woman eighteen years of age, who was admittted into the Hôtel Dieu, under M. Trousseau. This woman was vaccinated while in the hospital, in the beginning of October. The day after the vaccination the punctures were prominent, and surrounded by a slight inflammatory areola, with intense itching. Four or five days afterwards there were no longer any traces of the inoculation. This excited no surprise at the time, as the patient had previously been properly vaccinated. The patient left the hospital on November 9. In the beginning of December two ulcers, covered with thick scabs, were seen on the inoculated spots. These ulcerations were at first considered to be vaccine vesicles abnormally developed, with an unusually prolonged period of incubation. On January 11, 1862, upwards of three months from the date of the vaccination, this patient was re-admitted into the Hôtel Dieu. At this period the ulcerations on the arm were still unhealed; the corresponding armpit was the seat of multiple indolent bubo; and on the body, the arms, and the chin, was a syphilitic roseola, concerning the nature of which no one has hitherto expressed any doubt. The patient reported that this eruption had existed from the middle of December. It was followed by pains in the head, and indolent enlargement of the post-cervical glands.

M. Ricord now examines the patient at M. Trousseau's invitation, and reports that she is the subject of two indurated chancres on the left arm; that she has multiple enlargement of the glands in the axilla; and that she has specific roseola, typical of constitutional syphilis. This constitutional affection he moreover declares to have had its origin, its entrance into the patient's system, through the ulcerations on the left arm.

A much more startling series of facts have comparatively recently been brought to light by a sad tragedy enacted at Rivalta. Here a child, named Chiabrera, was vaccinated; from him another child, named Mazone, was vaccinated; with forty-five other children. Chiabrera we shall call the first vaccinifer, and Mazone the second vaccinifer.

A disease was conveyed from the first vaccinifer to thirty-nine children; from the second vaccinifer to seven children. Both vaccinifers were very ill, and one died three months after vaccination. The first vaccinifer communicated the disease to his mother; the second to his wet-nurse. Twenty nurses or mothers were known to have been similarly affected. In three cases the same disease was again communicated from the mothers to their husbands; and in three other cases the disease was communicated to other, previously healthy, children.

The annexed diagram furnishes a view of the progress of this terrible malady, previously (as would appear) unknown at Rivalta, a village containing not more than two thousand inhabitants:—



From the care and attention that have been given in England to the subject of vaccination, vaccino-syphilitic inoculation is extremely rare. I have never witnessed an example of the kind, but am able with Dr. Druitt's permission to reproduce the drawing of a case which he saw in Paris. It is represented in Plate VI. fig. 15, and shows the results of the inoculations and the secondary eruption as they existed at the same time.

A second series of cases of a like horrible nature to those which occurred at Rivalta, is related by Dr. Marone to have happened at Lupara. Dr. Marone ascribes the cause of the inoculation to the admixture of some blood with the vaccine lymph, and this is the explanation which is now generally received.

It has been demonstrated by direct experiment that the blood of a syphilitic patient (in certain states of the constitu-

tion) may be directly inoculated so as to produce a primary syphilitic sore.

On February 6, 1862, Professor Pelizzari inoculated Dr. Bargioni with the blood of a syphilitic patient, who had not been subjected to any specific treatment.

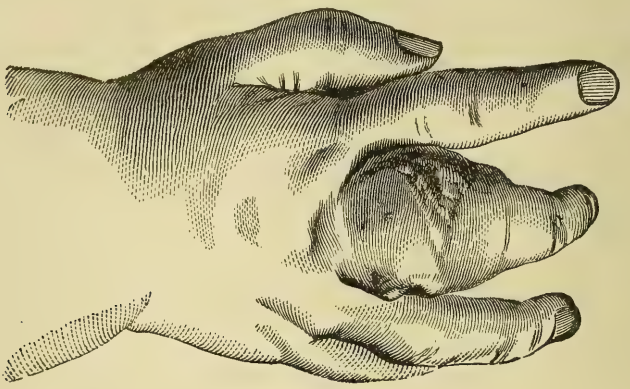
On the morning of March 3, Dr. Bargioni announced to Professor Pelizzari that in the centre of the inoculated surface he had noticed a trifling elevation which produced a little itching. Professor Pelizzari examined the arm, and found, at the point indicated, a small papule, of a roundish form, and of a dull-red color. There was then no induration at the base of the papule, nor any enlargement of the corresponding axillary glands. To prevent its being rubbed, it was covered with some dry charpie and diachylon. Professor Pelizzari examined it daily. On the eighth day the papule had augmented to the size of a twenty-centime piece. On the eleventh day it was covered with a very thin adherent scale, resembling silver paper, which, upon the two succeeding days, became denser and less adherent, and in its central part commenced to crack. On the fourteenth day two axillary glands became enlarged to the size of nuts, and were movable and indolent. The papule remained indolent, but its sensibility was slightly increased. On the 19th, pressure upon the crust caused a small amount of seropurulent matter to exude from beneath its edges, the pressure giving a little pain. The axillary glands had now become larger and harder, but continued indolent. There was no induration apparent at the base of the papule. On the 21st the scale was transformed into a true crust, which had commenced to be detached at its edges; and the part beneath was ulcerating. Slight induration now appeared at the base. On the 22d the crust was detached, and a funnel-shaped ulcer presented itself, with elastic and resistent borders, forming an annular induration. These edges were swollen, adherent, and obliquely inclined towards the base of the ulcer, which was covered with a very small amount of secretion. The pain was trifling. Dry charpie only was applied. On the 26th the ulcer had extended itself to the size of a fifty-centime piece. It secreted more, and the surrounding induration was considerably increased. Up to April 4, this ulcer remained stationary, but at that date its base appeared to be granulating. The corresponding glands remained swollen, hard, and indolent. There appeared at this date trifling nocturnal pains in the head, and the posterior cervical glands became somewhat enlarged. On April 12, there appeared upon the surface of the body, particularly upon the sides of the chest, and in the hypochondriac regions, spots of irregular form and of rose color, unattended by any inconvenience to the patient. The glandular swellings of the neck were well marked. This eruption extended itself, and became more confluent during the succeeding days. No constitutional disturbance, heat of skin, nor pruritus, accompanied this eruption, which went on increasing for eight days. On the 20th the cervical glands had increased in size and were harder. The chancre maintained its specific character, and exhibited no tendency to cicatrization. On the 22d the color of the eruption was decidedly coppery. Small lenticular papules were now perceived to be mixed with the erythema. The edges of the chancre had begun to granulate. Mercury was now commenced.

[The important subject of the transmission of syphilis by heredity, briefly referred to above, has attracted the special attention of late observers. It is now generally admitted that when both parents exhibit active manifestations of the disease, the child will prove to be what has been termed "intensely" syphilitic; that when the mother alone is infected, she will probably transmit the disease to her offspring; and with respect to the question of inheritance when the father alone is diseased, opinions are divided. In the latter event the child usually escapes, though exceptions are on record where diseased children have been born to the apparently healthy wives of infected husbands. It is proper to note, however, in this connection, that the law of Colles has never been effectually disproved. This law rests upon the ascertained fact that the mothers of syphilitic children are never infected at the breast by the diseased mouths of their offspring, an immunity not exhibited in the case of a healthy nurse whose nipples are similarly exposed. It has been suggested that the mother's immunity, in cases of this character, is due to a systemic modification analogous to that observed in the individual protected by vaccinia against variola. Respecting the limitation of the maternal power to transmit the disease, it is probable that infection occurring subsequent to the seventh month of pregnancy, works no harm to the unborn fœtus. The doctrine of *choc-en-retour*, according to which the father may infect the ovum of a sound mother, and the latter receive the disease subsequently during the development of the embryo, has been recently revived by Diday, of Lyons, but has failed of acceptance on a scientific basis. In connection with this subject, it should not be forgotten that, even when both progenitors are infected, sound children are occasionally, yet exceptionally, begotten, and, further, that as the parental disorder yields to time and treatment, the chances of inheritance by a second generation greatly diminish.

Abortion with intensely syphilitic ova, and miscarriage of the similarly infected fœtus, is the rule at first. These products of conception are usually macerated, the epidermis being raised into bullæ, and the viscera (especially the liver, lungs, thymus,

spleen, and kidneys) as well as the bones, are pathologically altered. Parrot, in France, and Taylor, in America, have well illustrated the interesting subject of osseous disease in inherited syphilis. All the bones of the skeleton may be involved in these changes, which may be periosteal or subperiosteal in their localization, and may result either in the formation of osteophytes and calcification with permanent thickening and deformity, or terminate by suppurative degeneration of the

Fig. 21.



Dactylitis syphilitica.

cellular elements. The degenerative processes occurring at the extremity of the long bones, may be followed by epiphyseal separation, leading to a form of pseudo-paralysis characteristic of the disease.

The acquired syphilis of infancy differs from that of adult years, chiefly in the tendency to the formation of mucous patches, condylomata, or the moister lesions of the skin upon the delicate integument of the child. The living infant who inherits the disease, usually exhibits the evidence of that fact before the fourth month of life, by the occurrence of bullæ, papules, pustules, and scaly lesions intermingled or not with fissures and abscesses. The child has a weazened, prematurely old expression, suffers from coryza and snuffles when mucous patches exist upon the Schneiderian membrane ; has a husky voice, and either dies from exhaustion or survives to display, very rarely, in later years, the tardier symptoms of inherited lues.

Hutchinson[1] has accurately described the dental changes in inherited syphilis. The permanent central incisors have a narrow cutting border, and are peg-shaped and notched. There is frequent coexistence of interstitial keratitis from the sixth month to the third year, insidious in its approach.

Syphilis of the infant is best treated by mercurial inunction, advantage being taken of its tender skin. Mercury by the stomach is, however, well tolerated, and when indicated, the iodide of potassium also, both being administered, at times, with advantage, through the milk of the

Fig. 22.

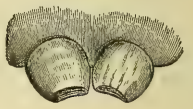


Fig. 22*a*.

Syphilitic teeth.

mother. It should not be forgotten that the secretory lesions of the inherited disease are capable of furnishing a contagious secretion.]

X. Constitutional Syphilis.

The symptoms generally known as those which constitute secondary syphilis usually manifest themselves within the third month after the introduction of the poison into the patient's system.

The access of this series of symptoms is usually marked by a certain amount of general disturbance. The patient feels feverish and uncomfortable ; the skin becomes dry, and the tongue perhaps coated. It occasionally, however, happens that the secondary or constitutional symptoms show themselves without the patient feeling any general inconvenience.

Lassitude, weariness, and pain in differ-

[1] Illustrations of Clinical Surgery. London, 1876, F. iii. pl. xi.

ent parts, frequently mark the progress of the disease. The skin loses its fresh and healthy color, and assumes often a sallow hue.

When the general system is thus affected by the syphilitic poison, it is probable that the nutrition of every part of the body may be thereby influenced. The same tendency to the separation of a plastic material from the other elements of blood may be manifested in any part of the body as in the original seat of the disease. These effusions are more or less organized, and take their characters from the structures in which they are formed. Thus, in the skin, the papillæ become inordinately developed; and if several of these unite together tubercles are formed. On the iris, the lymph effused forms fibrous bands, which unite it to adjacent parts and prevent its actions. If the periosteum of a bone be affected, the effused material ultimately becomes converted into new bone; and this process, from the unyielding nature of the parts, is attended with much pain, experienced chiefly at night, which has been supposed to be the period of growth. According to the constitution of the patient, the part affected may take on the adhesive, the suppurative, or the ulcerative form of inflammation; or any of these may terminate in gangrene, molecular or of larger masses. Hence a syphilitic affection which commences as a pimple, may at a subsequent period suppurate, or ulcerate, or a portion of its surface may be thrown off, as a small slough. Different names have been given to these different forms of disease; but it is obvious that as long as they are liable to pass one into another, no very accurate divisions can be made. Again: a division has been made with regard to the time at which different parts of the animal economy are affected. The skin, the throat, the eye, and the absorbent glands, are those in which the disease generally appears in the earlier stages of the complaint; and diseases of these parts have been called secondary symptoms: whereas the fibrous and osseous tissues and the deeper structures are, as a rule, affected later, and affections of these parts have been called tertiary symptoms. This distinction will be adopted for convenience of description, but it must not thence be inferred that there is any well-marked natural division; and, in fact, the so-called tertiary symptoms sometimes appear before the secondary, and the parts belonging to these respective classes are constantly found affected at the same time.

SECONDARY SYMPTOMS.

The specific induration around the infecting sore has been regarded as the first of the secondary affections. This is, however, not attended with any of the constitutional symptoms above referred to. At an uncertain date, but generally from four to seven weeks from the first appearance of this induration, the syphilitic fever, often very slightly marked, will occur; and in a great majority of instances this will be followed by an exanthematous eruption of the skin, often accompanied by sore throat. At the time that this occurs, a change may frequently be observed in the character of the original sore; a fresh effusion of lymph may take place in its neighborhood, or the sore itself may ulcerate in a way that it did not before. The nature of the sore will now become altered—a free secretion of pus will often take place from its surface. It no longer presents the characters of the adhesive inflammation only. It has, in fact, become one of the secondary symptoms of the disease. The inguinal glands, in like manner, which up to this period were indurated and enlarged only, will now sometimes show signs of increased morbid action. They may become tender to the touch. The thickening, originally confined to the glands themselves, may involve the surrounding cellular tissue; and it not unfrequently happens that an abscess will form either in one of the glands, or in the surrounding structure. These suppurating buboes are to be regarded as a part of the secondary symptoms; and their occurrence in no way invalidates the fact dwelt upon in section II., viz., that the sores which produce syphilitic infection of the constitution do not produce suppurating buboes, excepting from some accidental cause.

SYPHILITIC ERUPTIONS.

Roseola, the eruption which generally first succeeds the syphilitic fever, is of a rose-red color, not raised above the surface of the skin; disappearing upon pressure, and returning as soon as the pressure is removed. It appears in more or less rounded patches, giving a mottled appearance to the skin; when examined closely, each patch appears made up of a cluster of papillæ, more injected than natural. This eruption will sometimes disappear within a few days. If it persists, the papillæ forming each patch will generally become visibly enlarged, and the color of the eruption will gradually change to a copper tint. This color is a common characteristic of all syphilitic eruptions which remain for any length of time without suppuration or ulceration.

The syphilitic eruptions which follow this first efflorescence on the skin present a variety of appearances.

Lichen.—The papillæ of the skin fre-

quently are enlarged separately and scattered irregularly over the body. They form small hard elevations of a copper color, which terminate by desquamation or resolution. The enlarged papillæ are sometimes formed into groups, and then, occasionally, one much larger than the rest appears as a tubercle in the centre. This form of eruption has been described separately as *central tubercle.*

Syphilitic tubercle.—The same tendency, which has been traced throughout, to the exudation of a fibrinous or plastic material from the diseased blood, manifests itself particularly in this form of disease. The effusion takes place by a slow, gradual and uninterrupted process, and becomes perfectly organized as in the papular eruption; each tubercle appears as a small, full, and tense conical eminence, covered with a red and shining cuticle gradually, like other syphilitic eruptions, assuming a copper color. The tubercles may be scattered singly over the surface, or they may be seen in groups.

The syphilitic tubercles may assume any size from a large pimple to a split pea or bean. Their shape is generally round, but often they are irregularly oval. The cuticle thrown off from the surface of syphilitic tubercles is peculiarly thin, white and shining. It resembles small broken pieces of silver paper. When syphilitic tubercles appear on mucous membranes, they are generally irregular in shape, flattened, and but slightly raised above the surface. These peculiarities depend in a great measure upon the mucous membrane from which they spring being opposed to other parts, and consequently subject to a certain amount of pressure. The tubercular form of eruption of the skin generally occurs at a later period than the other eruptions, accompanied by the adhesive form of inflammation.

Syphilitic lepra commences like the mottled skin previously described, by the injection of circular groups of the papillæ of the skin. These may at first be seen separate, but soon the whole circular patch becomes equally involved; an effusion takes place into the substance of the skin, which causes a small flat elevation, the edges of which are sometimes raised higher than the centre. A large number of these patches, all nearly circular, may form on any part of the body. They have, like other syphilitic eruptions, more or less of a copper color, but this is often partially masked by a thin layer of epithelium, which is thrown off in thin white and shining scales. Patches of syphilitic lepra sometimes bear a strong resemblance to flattened syphilitic tubercles.

Syphilitic psoriasis occurs in the form of oval or irregular patches slightly raised above the surface. These are generally of a brown or copper color, and covered with epithelial scales of various degrees of thickness. They are not depressed in the centre, and are often traversed by cracks which show no tendency to become obliterated. This disease is much more persistent in its character than syphilitic lepra. It is frequently observed on the palms of the hands and the soles of the feet, but it may occur on any part of the body. Patches of syphilitic psoriasis will sometimes remain for months without undergoing much alteration in appearance.

Syphilitic psoriasis is very liable to be confounded with ordinary psoriasis. Dr. Anderson has enumerated the distinguishing characters of syphilitic psoriasis under the following heads: It is not usually very extensive. It generally occurs as a second stage to some other syphilitic eruption. Some of the patches may be moist, or covered with crusts, or even in a state of ulceration. The patches are usually small and in the shape of round spots, or circles, or segments of circles. The eruption is not usually on the elbows or knees. It is more on the inner than on the outer sides of the limbs. When confined to the soles of the feet or palms of the hands it is always syphilitic. The eruption in its chronic stage usually assumes a distinctly coppery tint. It often itches. It usually commences for the first time after twenty years of age.

The eruptions now described may be classed together as resulting from secondary adhesive inflammation; they are essentially of the same character, and require the same mode of treatment. Not unfrequently they will appear upon the patient at the same time, or will follow each other at successive periods. The tendency of these, as of other syphilitic eruptions, is to fade after a time, but to appear again and again, unless checked by treatment; after the disease has existed some time, they have, however, a greater disposition to assume an ulcerative or suppurative form, than to recur in their proper adhesive characters.

The same mode of treatment has been adopted generally for these eruptions, as for the primary disease to which they owe their origin.

Mercury, in some form, is the remedy that alone can be relied upon. As in the primary infecting sore, it may be given internally, or may be used in the form of ointment rubbed on the skin, or may be administered as a mercurial vapor-bath.

In private practice it may be convenient to give mercury internally, on account of the little observation which this plan attracts, and the apparent ease with

which it is followed. But, even with young men in the vigor of health, it will rarely happen that mercury can be taken sufficiently long in this way to cure the disease: at the end of perhaps two or three weeks, the digestive organs become disturbed by the constant irritation of the medicine; an attack of diarrhœa perhaps supervenes, which may be checked for a time by opium; but if the internal administration of the mercury be continued, some other form of inconvenience will arise; and practically, the remedy has to be given up, in the very great majority of cases, before the patient is cured. When the eruption occurs under these circumstances at a subsequent period, it presents often a more troublesome, and worse form of disease than if no mercury had been given; the long-continued irritation of the patient's digestive organs has produced an effect upon his system, and the diseased, as well as the healthy actions, of the body are consequently performed with enfeebled powers, and a lower type of affections are produced. From these considerations, the use of mercury internally has for many years past been used very sparingly in the author's practice.

The inunction of mercurial ointment is a very efficient way of bringing a patient's system under the influence of the drug; and the action may in this way be continued for the requisite length of time, provided the laborious process which it entails, and the dirty condition in which it leaves the skin, are not objected to. In the treatment of cases of eruption on the skin, it may, however, cause irritation in any of the spots upon which the ointment is rubbed, and may consequently have to be discontinued.

The mercurial vapor-bath is by far the least disagreeable mode of administering mercury; at the same time that it enables the surgeon to regulate the action of the medicine with the greatest nicety, it does not endanger the patient's powers, nor produce irritation in any part of the skin. A full description of its mode of application will be given in a future section.

Iodide of potassium has very often been used for the papular, tubercular, and squamous syphilitic eruptions. From three to five grains are generally given in solution three times a day. This medicine certainly has a great power in removing syphilitic eruptions and other forms of secondary and tertiary syphilis; but it does not, according to my experience, cure the disease. The symptoms disappear, the surgeon and the patient often congratulate themselves on the result, but within a few weeks the eruption appears again in the same, or in a somewhat different form.

Iodide of mercury is a very favorite medicine with many continental surgeons; a grain may be made into a pill and given three times a day, and this dose may be gradually increased to three grains.

Mercury given in this form is more easily eliminated from the system than when given alone, and it also produces a more visible and decided effect upon the patient's system.

The bromide of mercury has lately been recommended by Dr. P. Smith. It is given in the same doses as the iodide.

Iodide of potassium, or iodide of sodium, may be given internally, while the mercury is administered through the skin. These medicines probably then unite in the system, and produce much the same effect as if the iodide of mercury were given. This mode of giving the iodide of mercury has, however, the great advantage of saving the digestive organs and the liver from any irritation from mercury.

Sarsaparilla, useful in some forms of tertiary syphilis, has very little, if any, influence over the eruptions under consideration. Mr. Bromfield, formerly surgeon to the Lock Hospital, in his practical observations, says: "I solemnly declare I never saw a single instance in my life where it cured the disorder without the assistance of mercury." Mr. Pearson's observations led him to the same conclusion. We are, therefore, led to believe, although sarsaparilla is often given, even at the present day, for papular, tubercular, and scaly eruptions on the skin, that these affections, when they appear to have been benefited by that medicine, have in reality either in their natural course undergone a change for the better, or have been relieved by other medicines given at the same time as the sarsaparilla.

One source, and a very common one, observes Mr. Pearson, to which some of the mistakes committed upon this subject may be traced, is a persuasion that every morbid alteration, which arises in an infected person, is actually tainted with the venereal virus, and ought to be ascribed to it as its real cause.

Every experienced surgeon must, however, be aware that very little truth or reality exists in a representation of this kind. The contagious matter and the mineral specific may jointly produce in certain habits of body a new series of symptoms, which, strictly speaking, are not venereal, which cannot be cured by mercury, and which sometimes are more to be dreaded than the simple and natural effects of the venereal virus. Some of the most formidable of these appearances may be sometimes removed by sarsaparilla, the venereal virus still remaining in the system; and when the force of that poison has been completely subdued by

mercury, the same vegetable is also capable of freeing the patient from what may be called the sequelæ of a mercurial course.

Pustular syphilitic eruption.—When the syphilitic disease was first recognized at the end of the fifteenth century, the eruptions which it produced were frequently described as pustular. No very accurate description of these so-called pustules is, however, given; and, considering the vague nomenclature of the day, it may appear doubtful whether these were not in reality vesicular eruptions, such as were observed in some of the fatal cases at Rivalta. Pustular syphilitic eruptions do occur, but they are very rare in unimpaired constitutions, as the first general eruption.

From constitutional causes, the primary disease, which, in its normal course and in a healthy constitution, would present the characters of the adhesive form of inflammation, may soon after its first appearance suppurate, become phagedænic, or, in a few exceptional cases, it may be accompanied by a suppurating bubo. So the secondary form of disease, which, in a healthy person, would produce one of the eruptions characterized by the adhesive form of inflammation, may suppurate, ulcerate, or become phagedænic.

The most common form of pustular syphilitic eruption arises from the transformation of one of the forms of the adhesive into the suppurative inflammation. A papular or tubercular eruption will appear in the first instance, and the plastic material effused will be completely organized; the patient may then have an imperfect or irregular course of mercury, or his health may be deteriorated from other causes, and the eruption will then reappear, and the summit of each spot will contain a material incapable of being organized, which will become more or less perfectly transformed into pus.

The proper syphilitic pustular eruptions are divided by Cazenave[1] into three kinds, which he describes as follows:—

1. In one form the pustules (*psydraceous*) are either small and narrow, or of a large size, elevated, and round. They have a hard base, and are surrounded by a copper-colored areola. The pustules themselves are of a dull reddish hue, and are developed in successive crops, presenting examples of the disease in its origin, maturity, and decline. Their progress is slow, and the inflammation attending them moderate; in some cases, however, it destroys the true skin, and leaves behind it a small, white, circular scar, depressed in the centre, and not larger than a pin's head. These scars, which have been erroneously supposed to follow papules, because the affection has been confounded with a papular eruption, are in a great majority of cases the sequels of true pustules. This form chiefly occurs on the face and forehead, where it bears some resemblance to acne rosacea; but it may appear on every part of the surface. The pustules dry off, and form a small grayish scab, which separates, and may leave behind it either a cicatrix, or some injection of the skin. The psydraceous pustules rarely terminate in ulceration, and then only when several of them have become confluent.

When seated on the limbs, these pustules present a different appearance. They are sometimes of the size of a lentil, numerous, but slightly elevated above the surface, with a hard base, and contain a very small quantity of yellowish-white matter, which presents a strong contrast to the copper-colored elevation on which it rests. They are not followed by ulcers; a thin scab forms on them, which is followed by a scar, or sometimes by a livid discoloration, or a small chronic induration.

This form of syphilitic eruption (called also *lenticular pustular* eruption) is the most common of all those which assume the pustular character, and is the one most frequently taken for the papular form; doubtless in consequence of the rapidity with which it passes into the purulent stage, and the persistence of the induration which so early follows, and also on account of the peculiar arrangement of the eruption, which is always spread over a large surface in isolated elevations.

2. *Syphilitic impetigo.*— This form is usually preceded by slight malaise, and commences with redness of the affected points; this is followed by small collections of purulent matter, forming irregularly-shaped patches, more or less confluent, resting upon surfaces of a coppery-red color, which are soon covered by scabs, irregular in shape, harder, darker colored, and more adherent than those of common impetigo. Beneath these scabs are characteristic ulcerations, which are followed by scars, varying in extent and shape. This is the form called *pustulo-crustaceous* syphilitic eruption. It may affect any part of the surface, but more frequently attacks the face. It sometimes appears on several places at the same time, but has no tendency to spread to neighboring parts. It is always secondary.

3. In the third variety of syphilitic pustular eruption, the pustules are still larger (*ecthyma syphiliticum*), and resemble those of ecthyma. They are few in number, isolated, and chiefly occur on the limbs, and especially the legs. They appear at

[1] Manual of Diseases of the Skin, by Burgess.

first under the form of a large livid spot, about the size of a shilling, or larger. The epidermis is now raised over a considerable portion of the spot, by a grayish, seropurulent matter; the elevation increases slowly, and is always surrounded by a broad copper-colored areola, quite different from that of ordinary ecthyma, which is of a violet-red. After a few days, the pustule breaks, and the contained matter concretes in a dark hard scab, which gradually becomes thicker, and fissured at the edges, being of a circular shape. All this occurs without any local inflammation: there is little heat, and no pain; the scabs are extremely tenacious, and may remain for an indefinite time without separating. When they do come away, we find underneath them deep round ulcers, with sharp-cut hard edges, of a purple color, whilst the bottom is grayish and ill-looking. They have little tendency to spread. The scabs now gradually form again, and are frequently renewed, until, under the use of appropriate means, they become thinner, while the ulcers get clean and heal, leaving behind them circular and lasting cicatrices.

This is the most common form of the syphilitic pustular eruption, and the one which usually occurs in new-born children. Here the pustules are broad, superficial, flat, of an oval shape, and in great numbers; the scabs are dark and thick, and conceal small ulcers underneath. The countenance of the patient presents, at the same time, a peculiar appearance, which it is difficult to describe; the skin is of an earthy hue; the child is emaciated, the face is drawn in and marked, like that of an old person, by numerous wrinkles, while the whole body exhales a most disagreeable odor.

Treatment of pustular syphilitic eruptions.—It will, I believe, be found a universal rule in the treatment of both primary and secondary syphilis, that mercury will not agree with patients during the time that active suppuration, on however small a scale, is taking place. Other remedies have then to be sought; among these the iodide of potassium occupies the first place. This remedy may be given alone, or in combination with iron or other tonics. The usual dose is from three to five grains, three times a day, in solution. This medicine has a marked effect in removing the symptoms in almost every form of secondary syphilis. Practically this is a great advantage; but it certainly does not cure the disease in the same way as mercury does, when that medicine is properly administered and can be conveniently borne.

Larger doses of the iodide of potassium are often given, as much as ten or fifteen grains three times a day; but it is doubtful whether these doses possess any advantage over the smaller ones.

Guaiacum in the form of decoction was supposed, during two centuries, to possess antivenereal properties; and we are told by Mr. Pearson that its reputation was supported by well-attested narratives in a great number of instances where no mercury had been employed, or where that medicine had done no permanent good, or where the patients had suffered injury from it instead of finding advantage.

After a careful investigation of the properties of guaiacum, the following are Mr. Pearson's conclusions with regard to it: "The decoction commonly excites a grateful sensation of warmth in the stomach; it gives a sense of dryness to the mouth, and creates thirst; it also increases the natural temperature of the skin, and renders the pulse more frequent. If the patient drink the decoction warm and lie in bed, it generally proves moderately sudorific; and this effect may be heightened as much as we please, by employing the hot bath, the vapor-bath, antimonials combined with opium, or the pulvis ipecacuanhæ compositus. When the decoction has been continued during ten or twelve days, in the quantity of four pints each day, the patient often complains of its producing the heartburn, accompanied with flatulence; and he is usually costive during the whole course. If the person expose himself freely to the air while he is taking this medicine, the secretion of urine will be augmented, but no sensible alteration will take place in the state of the skin.

"When I have exhibited the decoction of guaiacum in pains of the bones, as they are called, confining the patient at the same time to bed, and enjoining a diet consisting of fluids only, I have rarely seen any beneficial consequences result from the use of it, except where it acted as a sudorific; and in this respect I think its qualities manifestly inferior to antimony or volatile alkali. In several instances, after persisting in a course of it during four or five weeks, I have not gained any material advantage; and I have remarked, that when the dolores osteocopi were not connected with some morbid alteration of the structure of a part, this medicine was of little avail. When the strength and vigor have been reduced by a successful mercurial course, with confinement to the house, and where a thickened state of the ligaments or of the periosteum remains, or where there are foul indolent ulcers, these sores will often heal, and the enlarged membranes will subside, during the administration of this decoction.

"The decoction of guaiacum will often suspend the progress of certain secondary symptoms of lues venerea for a short time,

such as ulcers of the tonsils, venereal eruptions, and even nodes; but I never saw one single instance in which the powers of this medicine eradicated the venereal virus. It has been recommended by many people to combine guaiacum with mercury, with the intention of improving the specific powers, and of counteracting the injurious effects of that mineral; the advantages to be derived from this compound mode of treatment are by no means well established, for guaiacum is certainly no antidote to syphilis."

Mr. Pearson's opinion with regard to the virtues of sarsaparilla, founded as it was upon a very large experience and a great number of experiments, is perhaps as valuable and correct as can be obtained. "While I reject it," says he, "as a specific, I would by no means disparage it as a medicine possessing no valuable qualities. In those cases where the malignant powers of the virus have proved materially prejudicial to the health, so that the patient cannot enter upon the use of mercury with propriety, the decoction and powder of sarsaparilla will often retard the destructive agency of the venereal poison, and repair the breaches made in the constitution; it may be sometimes given with advantage during a course of mercurial frictions, when it does not occasion a determination to the bowels; and it will almost invariably remove many of the most troublesome sequelæ of a course of mercury."

Nor are the salutary properties of the sarsaparilla-root useful in those diseases only that are either immediately or remotely connected with syphilis; its beneficial effects are often demonstrated in the treatment of foul, intractable, spreading sores in more than one form of scrofula.

In all diseases characterized by want of power, bark may be advantageously employed; and it may often be most beneficially used in cases of syphilitic eruption, where, either from some constitutional peculiarity, or from the long continuance of the disease, or from the debilitating effects of the remedies employed, a want of power is manifested in a patient's system. It may conveniently be given during a mercurial course, or after the mercury has been discontinued. The beneficial effects of bark are, however, most manifest in cases where destructive ulceration or sloughing occurs.

Opium is, next to mercury and the iodide of potassium, perhaps the most useful remedy in the treatment of venereal diseases; and with regard to it Mr. Pearson's opinion may again be taken. He says: "An experience of nearly twenty years has taught me, that when it is combined with mercury, the proper efficacy of the latter is not in any measure increased; that it would not be safe to rely upon a smaller quantity of the mineral specific, nor to contract the mercurial course within a shorter limit, than where no opium has been employed.

"This representation will not, I presume, admit of controversy; yet we frequently hear people expressing themselves upon this head, as if opium manifested some peculiar qualities in venereal complaints, of a distinct nature from its well-known narcotic properties, and thus afforded an important aid to mercury in the removal of lues venerea. Perhaps it may not be unuseful to disentangle this subject from the perplexity in which such indefinite language necessarily involves it.

"Opium, when given in conjunction with mercury, by diminishing the sensibility of the stomach and bowels, prevents many of those inconveniences which this mineral is apt to excite in the primæ viæ; and thus its admission into the general system is facilitated. Mercury will likewise often produce a morbid irritability, accompanied with restlessness and insomnolescence; and it sometimes renders venereal sores painful and disposed to spread. These accidental evils, not necessarily connected with venereal disease, may be commonly alleviated, and often entirely removed, by a judicious administration of opium; and the patient will consequently be enabled to persist in using the mineral specific. It must, however, be perfectly obvious, that opium, in conferring this sort of relief, communicates no additional virtues to mercury; and that, in reality, it assists the constitution of the patient, not the operation of the medicine with which it is combined.

"The salutary effects of mercury as an antidote may be diminished, or lost, by the supervention of vomiting, dysentery, etc. Opium will often correct these morbid appearances, and so will spices, wine, an appropriate diet, etc.; yet it would be a strange use of words to urge, wherever these articles of food were beneficial to a venereal patient, that they concurred in augmenting the medicinal virtues of mercury. It may be supposed that the majority of medical men would understand by the terms 'to assist a medicine in curing a contagious disease,' that the drug conjoined with the specific actually increased its medicinal efficacy; whereas, in the instances before us, it is the human body only which has been aided to resist the operation of certain noxious powers, which would render a perseverance in the antidote prejudicial or impossible.

"The soothing qualities of this admirable medicine can scarcely be estimated too highly; yet we must beware of ascribing effects to them which have no existence; since a confidence in the antivene-

real virtues of opium would be a source of greater mischief than its most valuable properties would be able to compensate."

SECONDARY SYPHILITIC VESICULAR ERUPTIONS.

From some peculiarity in the patient's constitution, or from some want of power in carrying out the natural processes of the disease, the syphilitic eruption may be accompanied by an effusion of serum only. The diseases thus produced have received a variety of names, according as they have resembled other diseases of the skin. Thus we have described *syphilitic herpes*, *syphilitic eczema*, the *varicelloid syphilitic eruption*, the *impetiginous syphilitic eczema*.

When the effusion of serum beneath the cuticle is larger, bullæ are formed instead of vesicles, and then the disease is described as syphilitic pemphigus. These all are only accidental modifications, and do not belong to the essential nature of the syphilitic disease. They may pass one into another, and be preceded or followed by other forms of eruption. They do not, consequently, require any separate and distinct mode of treatment.

SECONDARY SYPHILITIC ULCERATIONS.

About the period when a patient's constitution gives evidence of being affected with the syphilitic poison, the original primary chancre will often ulcerate in a way that it had not done before; at this period also, as the consequence of that ulceration, the corresponding lymphatic glands will become affected, and sometimes suppurate, as has already been explained. These ulcerations must be regarded as altogether of a secondary nature, and they are frequently healed with much difficulty. The secondary inflammation of the skin may, in like manner, in any situation terminate in ulceration; but this ulceration is generally not attended with suppuration of the corresponding lymphatic glands. The absorbent glands, which receive the lymphatics from the ulcers now under consideration, become often enlarged, especially at the back part of the neck; but they do not, as a rule, suppurate.

Large portions of the skin are often destroyed by these secondary ulcerations; and if they occur upon the face, they leave great disfigurement.

No remedy is so efficacious for these secondary ulcerations as the calomel vapor-bath. It generally happens, on account of the rapid progress of the ulceration in these cases, that it is advantageous to bring a patient's system rapidly under the influence of mercury; and then the general calomel-bath should be used every night, taking care to have the parts ulcerated as much exposed to the vapor of calomel as possible. But in cases where a general mercurial affection of the system is not desirable, a local fumigation will answer the purpose. Different plans are adopted for the local calomel fumigation; the only essential condition is, that the volatilized calomel should come in contact with the ulcerated surface, which it then covers in a state of most minute subdivision.

The ordinary fumigating-lamp, used without water, answers the purpose of local fumigation extremely well. Five or ten grains of calomel may be volatilized, and the ulcerated part should then be held directly over the lamp. The vapor of calomel ascends perpendicularly, and is deposited upon the first surface with which it comes in contact.

There is a form of ulceration in the skin of patients affected with secondary syphilis which does not depend upon the direct influence of the syphilitic poison, but which is extremely liable to be mistaken for those that do. The ulcerations now referred to generally occur where some portion of bone about the skull has become affected, and where, either by direct irritation or by reflex action, the nerves going from the brain, or spinal cord, are kept in a chronic and persistent state of morbid irritability.

Case.—Mr. ——, a tradesman in the city, came under my observation on March 3, 1859. He gave no distinct history of any primary syphilitic affection, but a well-marked and accurately-defined induration existed at the upper part of the root of the penis.

Eight years previously, an ulcer made its appearance on the forehead, immediately over the left eye. This spread rapidly in every direction; about the same time the skin over the right elbow began to ulcerate. This ulceration extended upwards and downwards, and involved the skin of the whole arm. The ulceration on the forehead healed, but that on the arm had never entirely done so. Three years after the commencement of this ulceration, he had a severe convulsive fit; he was not insensible, but there was violent contraction of the muscles of the jaw and back. During the continuance of the spasm no food could be administered. The muscles of the face were likewise affected.

In the year 1857 it became evident that the bones of the skull were extensively diseased. He was now one day suddenly seized with violent spasmodic contractions of the right side of the face, which lasted half an hour, without loss of consciousness. Four months later a second attack followed, of a more severe character. This lasted six hours and a half, was accompanied by partial paralysis of the right side of the body, and tremor of the limbs. Subsequently to this,

several milder attacks occurred, and increased in frequency. He always had a warning of these attacks. His face became flushed, there was a difficulty of articulation, and tremor of the muscles on the right side of the face.

This patient underwent a great variety of treatment by different medical men, and was, for a considerable period, an out-patient at St. Bartholomew's Hospital. On September 13, 1859, he was admitted into the Lock Hospital; an ulcer still at that time existed on the outer side of the right forearm. The cicatrized skin, from the shoulder to the wrist, firmly bound down the parts beneath, and the arm was, in consequence, very much reduced in size. There was no motion either in the elbow or wrist joints. The hand was greatly swollen and œdematous. The frontal and parietal bones were in several places denuded. Extensive portions of their outer tables were either carious or necrosed.

All ordinary remedies having been previously exhausted, this patient was placed under the influence of chloroform, on October 25, and the trephine applied in several places over the right parietal bone. In the part apparently the most diseased, the whole thickness of the skull was removed, to the extent of one crown of the trephine. In other places, the outer and middle tables only were taken away. The exposed dura-mater, where the whole thickness of the skull had been removed, bled freely, and did not appear to be covered by any deposit. The surface of bone which lay in contact with it was slightly eroded, and was also perforated by numerous very minute holes.

October 26. Had slept well during the night.

November 5. Had two fits last night similar to those he had had previous to the operation. They were reported by the house-surgeon as "of an epileptic character, accompanied by loss of voluntary power."

November 12. General health improved. Healthy granulations from the scalp. The ulcer on the arm showed a disposition to heal.

November 27. Had a slight fit which lasted about a quarter of an hour. During this time he was quite conscious, but the lower jaw was fixed, and the muscles of the face were slightly convulsed. From this time until he left the hospital, on December 23, there was no recurrence of the fits. The wounds in the scalp assumed a healthy aspect, although there were still some small portions of bone which remained uncovered. The wound in the arm became reduced to the size of a fourpenny piece, and ultimately healed.

SECONDARY SYPHILITIC DISEASE OF MUCOUS MEMBRANES.

When a portion of mucous membrane becomes exposed for any length of time on the surface of the body, it gradually assumes the characters of skin, and becomes covered by cuticle. Secondary syphilitic eruptions here present the same characters as upon the true skin; but in the mucous membrane itself the appearances of these eruptions are necessarily modified. These membranes are little prone to the adhesive form of inflammation; and although they may be affected at the same time and from the same cause as the skin, yet the peculiar characteristics of the adhesive inflammation will not in them be generally fully developed. In those situations, however, where the mucous membrane joins the skin, and especially when from exposure and irritation it has become thickened and assumed the nature of skin, the different forms of syphilitic eruption will be well marked.

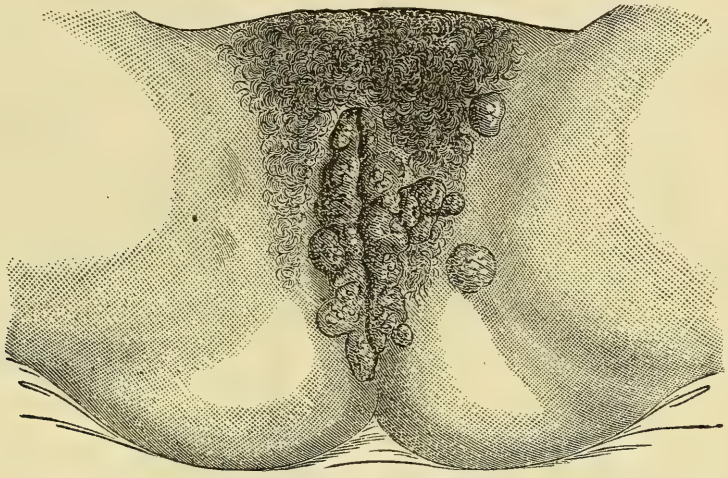
Every form of syphilitic affection of the skin has its counterpart on the mucous membranes; but the appearances will be modified by the comparative thinness of the structure, by the absence of cuticle, and by the little disposition these parts have to take on the adhesive inflammation. There are some of these which require a particular notice.

Mucous tubercles correspond to tubercles upon the skin. They have generally a more extended base, with a flat surface, or the edges raised above the centre. Although dependent in their origin upon the adhesive form of inflammation, yet they soon suppurate, and so far lose their original character. Mucous tubercles are much more easily influenced by local treatment than tubercles on the skin. A solution of bichloride of mercury, one or two grains to the ounce, or some mercurial ointment, or calomel powder, are very effective applications. The mucous tubercles affect the inside of the cheeks, the arches of the palate, the lips, the parts of generation, and the rectum. In the latter situation they are very likely to be mistaken for warts, from which, however, they ought carefully to be distinguished. Both may be communicated by impure contact; but the mucous tubercle is a secondary syphilitic affection, requiring constitutional treatment; the wart is a local disease, requiring only local applications. (See Fig. 23, p. 221.)

Deep ulcer of the tonsils commences in general without producing pain or other inconvenience. The mucous membrane is of a livid red color, and passes rapidly into a state of ulceration. The ulceration spreads, extending in every direction alike, and often produces a deep circular ulcer with sharp edges. It has often a yellowish base; but this varies according to the nature of the secretion which adheres to it. This ulcer has been supposed to be particularly influenced by the bichloride of mercury given internally; an eighth of a grain may be given, in decoction or tincture of bark, three times a day.

The mucous membrane of the pharynx and larynx is liable to be affected in secondary syphilitic disease, the former probably more frequently than the latter; but on account of the importance of the parts concerned, the latter has been described separately under the name of *syphilitic laryngitis*. This disease is sometimes accompanied by a fixed pain on a level with the thyroid cartilage, and there is occasionally evident swelling externally; the voice, breathing, and deglutition may all

[Fig. 23.



Condylomatous vegetations about the vulva. (From Bumstead, after Jullien.)]

be more or less interfered with. There is generally a hacking cough with attempts to expectorate, and some puriform matter streaked with blood is occasionally expelled.

If the disease continues, it is sometimes accompanied by emaciation, night-sweats, and dangerous exhaustion of the patient's system. Portions of the hyoid bone, or of the thyroid or cricoid cartilages, may be destroyed by this disease, and pieces of those cartilages have been known, when disengaged, to pass down the bronchi into the lungs.

Syphilitic iritis will be considered under the head of DISEASES OF THE EYE.

[The symptoms of the psychoses of the fever of secondary syphilis are analogous to those produced by alcohol, narcotics, and essential fevers, and at times require mechanical restraint of the patient, especially if inunction be employed therapeutically.[1] According to the best accepted nomenclature, syphilitic eruptions upon the skin are designated and classified as macular, papular, pustular, pigmentary, vesicular, squamous, and tubercular syphilides. Thus such terms as "syphilitic lichen" and "syphilitic eczema" are properly excluded from the category. Viewed as a whole, their general characteristics are important in a diagnostic point of view. Thus they are usually polymorphic; symmetrical in their earlier, and asymmetrical in their later manifestations; unaccompanied by subjective sensations, as a rule; circular or partially circular in outline; and resemble in color the tint which Swediaur compared to that of raw ham. The type of the cutaneous exanthem is clearly to be recognized in the papule, developed or not from the macular syphilide, scaling at apex or base, pushing upward before it a thinned or exfoliating epidermis as in the palm or sole, enlarging by plastic processes into the tubercle or cutaneous gumma, developing pustule or subsequent ulcer at its apex, or finally itself degenerating into the characteristic syphilitic exulceration, of relatively rapid progress, sloughy floor, clean-cut edges, and foul secretion. Permanent relics of this last-named destructive process are the smooth, circular, slightly-depressed, and delicate cicatrices, usually non-attached, whose pigment clears at the centre, leaving purplish, light-chocolate, or dark-brown peripheral circles. The rare and very exceptional forms of vesicular syphilides might well be omitted altogether from the list, depending as they do wholly either upon causes operating externally, or upon the irritant effect of medicines swallowed for the relief of the disease.

Keyes[1] has well drawn the diagnos-

[1] Kiernan. Chicago Journal of Nervous and Mental Diseases, July, 1880, p. 449.

[1] The Venereal Diseases, etc. New York, 1880, p. 149.

tic differences between the papular syphilide and the lesions in *Lichen planus*. The color of each eruption is similar, but, in the last named, the papules are solid, differ in size, tend to form patches, occur in lines rather than circles, and are umbilicated. The palms and soles are here also much more apt to be exempt; and there is no history of syphilis, nor coincident adenopathy. We have seen one of the rare forms of the quinine exanthem assume the lichenoid type, and take on the suspicious hue of the lenticular syphilide. A few hours' delay will, in such cases, make the diagnosis clear.

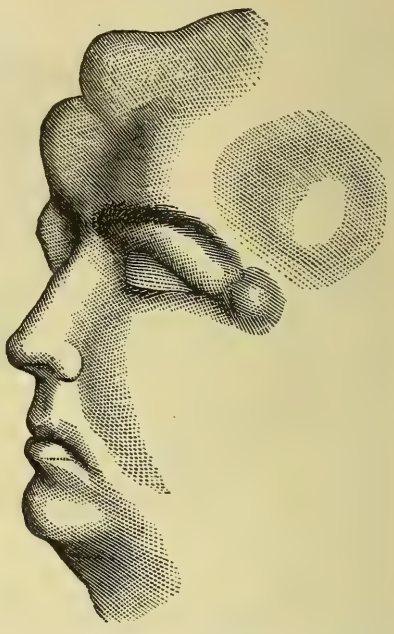
The pigmentary syphilide is a dirty-brown to black irregular mottling of the surface, usually of the neck and shoulders of blonde women, unaccompanied by subjective sensation, and produced by pigmentation, at first involving the macular lesion, and subsequently the peripheral integument. It occurs during the first year after infection, and is usually the result of uncleanliness.

The importance of recognizing the characters of the palmar and plantar syphilide can scarcely be overestimated. In one form, split-pea-sized, clean-cut circles appear, exhibiting, centrally, a delicate, newly-formed epithelium, and walled in by a whitish, slightly-undermined, and dense stratum corneum. In another form, usually later of appearance, yellowish or livid patches are visible in the palms and soles, which extend and deepen, giving origin to fissures which may terminate by ulcerative processes.

Besides the lesions of mucous membranes named by the author, should be mentioned scaly patches and gummata. The former are chiefly visible in the buccal membranes, and are flat, bluish and whitish, irregular epidermal accumulations, bleeding when roughly handled, and to be distinguished from the less sensitive *ichthyosis linguæ*. Gummata, found chiefly in the later periods of syphilis, usually degenerate into deep, serpiginous ulcers, of slow or rapid course, occasionally very destructive, and involving irreparable loss of tissue and constitutional cachexia.

The treatment of integumentary lesions of secondary syphilis, including those of the mucous surfaces, is practically the treatment of the constitutional disease. But little reliance is placed to-day upon the several vegetable remedies named by the author. Mercury by the mouth, or applied externally by inunction or fumigation, or injected subcutaneously, accomplishes the best results. For the purpose of inunction, the oleate of mercury, in the strength of the five, ten, or twenty per cent. preparation has become more popular than the officinal ointments, which, though cheaper, are less cleanly. In the strength last named there is produced occasionally mild erythema, or slight pustulation of the surface. The five per cent. preparation answers well as a topical

[Fig. 24.



Gummata of head and face (Bumstead, from Jullien.)]

application to several of the cutaneous lesions. Bamberger's solution of the albuminate of mercury is preferable when the metal is injected subcutaneously (*e. g.*, in hospital patients, completely under the supervision of the surgeon), as by this method there is less irritation of the skin at the site of the puncture. In the thickened and indurated forms of palmar and plantar disease it is advantageous to dip the affected surfaces for a short time in water that is sufficiently hot to slightly macerate the epidermis, which can be subsequently medicated by appropriate unguents containing mercury, either in the form of the bichloride, the red oxide, the nitrate, or even the oleate. The use of the nitrate of silver, or solutions of corrosive sublimate, is often indispensable in the local treatment of the lesions of the mucous membranes.]

XI. Tertiary Syphilis.

In tertiary syphilis there is the same tendency to the effusion of a plastic material from the blood that we have traced throughout. Indolent nodules are formed in the skin, which very slowly desquamate, or ulcerate, or become phagedænic. In the cellular tissue circular deposits are

formed, which after a considerable time become softened down. The skin over them breaks, and a ragged ulcer is left, with overhanging edges, the cellular tissue having been destroyed to a greater extent than the skin.

In the substance of the heart, in the liver and other internal organs, even in the structure of nerves, the same deposit may sometimes be found. These formations occur in irregular masses, often of a more or less circular form, and may remain probably without undergoing any material change for a very considerable period. There is little doubt but that, under appropriate treatment, they may be entirely re-absorbed. These tubercles must be distinguished from the results of ordinary secondary inflammation, such as occur after surgical injuries and operations. But, I believe that patients laboring under syphilis, even in its tertiary forms, are more liable to secondary deposits after surgical operations than others.

Tertiary syphilis, in one form or another, may probably affect every structure of the body; but the diseases thus produced so much resemble those that arise from other causes, that from the morbid changes alone, independently of the history of the case, it would often be impossible to recognize their true nature. A general description of some of the most important tertiary syphilitic affections will now be given.

Diseases of the skin and mucous membranes.—These consist mainly of ulcerations of a peculiarly unhealthy and persistent character, attacking various parts of the body, but chiefly portions of the face, nails, ears, and mucous membranes of the various openings of the body. In many instances no secondary affection of the part involved has preceded these ulcerations; whilst in others, and especially in those which are found on the face, the disease seems to consist of an extension of ulceration from a previously existing secondary sore. The parts of the face usually attacked are the nose and lips. A tubercular nodule is commonly first noticed. This becomes a hardened copper-colored mass, varying in diameter from the eighth of an inch and upwards. It often remains for many months without undergoing any material change, and then perhaps in some temporary depression of health it will break out suddenly into an open sore, and extend itself by rapid ulceration; or the ulceration may be more slow and gradual, eating, perhaps, through the cartilages of the nose, and reaching to its inner cavities, with more or less destruction of the sense of smell, and a decided change of voice. Occasionally, the ulceration begins from within, and extends outwards, producing similar destruction of parts. If the ulcerative action should not be arrested, it may progress to the deeper structures, attacking the bones of the nose and all the parts in its neighborhood, and completely destroying the sense of smell.

The disease of the lips commonly begins with a few cracks in either lip, which, like the preceding, may remain for weeks or months, and then ulcerate extensively.

Onychia.—The parts about the nails are liable to similar ulcerations. That most generally observed is an ulceration of the root of the nail, of an obstinate and unhealthy nature, of a dark, almost black color, and surrounded by a deep copper-red margin. It is a form of onychia extremely difficult to eradicate, as the ulceration is very apt to return. It occurs either on the fingers or toes, though most commonly on the former. Ulcerations also frequently occur between the toes, and are characterized by a very offensive discharge. The best treatment for syphilitic onychia is to scrape the nail quite thin; rub it with nitrate of silver, and wait until it separates. At the same time a lotion of nitrate of silver should be applied constantly, by which the extremity of the finger or toe becomes black, hardened, and a little sensitive. Sometimes the nail can be easily separated in this way. If not, it must be enucleated, and it is the shortest course to remove the fold from which the nail springs, or destroy it by caustic; otherwise there is sure to be a reproduction of it. Lotions of liquor sodæ chlorinatæ are very useful, followed by red oxide of mercury ointment, or by the application of a solution of nitrate of silver. It is essential, in most cases, that the patient should take mercury; and local calomel fumigation has been found useful. When the nutrition of the skin is affected, the bulbs of the hairs are involved. The hair, being imperfectly nourished, becomes cracked, dry, and split at its extremities. It often breaks off short at the roots, and comes away in considerable quantities in the comb. When the bulbs are much diseased, the hair is not reproduced, and partial or even entire baldness is the result. This has been called *alopecia*. It may affect the beard, the eyebrows, and eyelashes. A case is recorded by Vidal where it was complete, causing total loss of hair over the whole body.

The mucous membranes most liable to attacks of tertiary syphilitic ulceration are those covering the tongue, gums, rectum, vagina, and os uteri. There is nothing remarkable about the two former, except that, as the parts are more freely supplied with blood, the action is apt to be more energetic and rapid than in other cases. Accordingly ulcerations of the

tongue are often seen of large size, even soon after it has become affected.

When the gums are diseased, the teeth frequently become involved and lost.

Diseases of the teeth.—The following remarkable and highly interesting case is taken from Dr. Marston's most valuable paper in the forty-fifth volume of the Medico-Chirurgical Transactions :—

Gr. D. C., aged twenty-eight. Upon April 23, 1856, this man had connection. Upon May 18 following he was admitted into hospital with a glandular swelling in each groin. He discovered afterwards that two soldiers had caught a venereal affection from the same woman. There were many glands affected in both groins, and one upon the left side inflamed and threatened suppuration, and was opened by caustic potash. Subsequently an abscess appeared in the right groin, and was similarly treated. No sore of any kind existed on the penis, nor was there any urethral discharge, or cicatrix, or mark on the penis. Six weeks afterwards he suffered from a red rash over the whole body, and the skin came off in scales. This exanthem was followed by the appearance of numerous pustules, and iritis of the right eye. For these symptoms he was treated by mercurials for a fortnight, but his mouth was not affected. He subsequently took large quantities of iodides in the decoct. sarsæ comp. At the end of two months he was discharged cured (?). About seven or ten days afterwards he was re-admitted with "rheumatism in all his bones," particularly the legs. The rheumatism prevented him sleeping at night. After about four months' further treatment he was discharged cured, but he has never enjoyed the health he had before these attacks.

In the beginning of 1858 his teeth began to decay in the most curious manner. A dark spot would first appear upon the front aspect of the enamel, close to the gum. The lateral incisors of the upper jaw were first affected, and disease of the remaining front teeth speedily followed. This discolored spot became the seat of caries, and a minute circular hole resulted, situated in the middle line of the tooth, bordering upon the gum. The disease in each tooth gradually advanced from before backwards, extending laterally at the same time, and making its way in a very definite manner, until the line of caries passed through the tooth, and severed it at its junction with the fang. He has lost the upper teeth in this way. The two central incisors, however, are not quite destroyed; the disease in these has nearly severed the crown from the fang. The lower teeth have commenced to be affected in a similar manner. A line of caries has appeared upon the incisor and canine teeth, exactly at the junction of the crown and fang, and threatens their destruction.

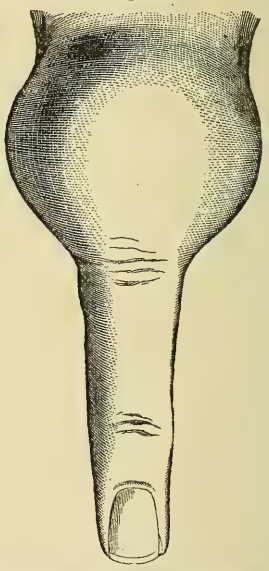
Dr. Marston informs me that he has seen this very peculiar disease of the teeth follow the same course in two other cases. He directs attention to an interesting paper, read June 25, 1862, by Dr. Roberts, of Manchester, upon two cases of double facial paralysis, apparently due to syphilitic disease, wherein there was a curious destruction of the teeth ; and he refers to a similar case by the late Dr. Todd, in his volume of Clinical Lectures upon Nervous Diseases.

Diseases of periosteum, bones, and joints.—Perhaps the most important of all these tertiary affections are those which attack the bones and their coverings.

They may be included under the heads of periostitis, acute and chronic ; nodes and exostoses ; inflammation of bone ; caries and necrosis.

Acute periostitis is a rather rare result of syphilis ; but when it occurs, it is apt to be extensive and destructive. Chronic periostitis is very common. It is attended with great pain at night, and aching at every change of temperature or weather.

[Fig. 25.



Osseous Dactylitis (from Bumstead, after Bergh).]

The interior as well as the surface of bones may be affected. The cancellous structure becomes thickened, condensed, and often much harder than natural. Fixed and long-continued pain in the bone, without much tenderness of its surface, may characterize this condition. The pain appears to rise from the pressure produced by the increased formation of bone, and is relieved, often permanently, by making an opening through the crust of the bone with a trephine. No fluid is found in the interior of the bone on these occasions.

Caries and necrosis of bone occur as tertiary forms of syphilis in the same parts as from other causes; the former in the cancellous structure, and the latter in the shafts of long bones or the dense parts of others. Necrosis is generally the result of acute periostitis. Caries is almost always produced by an extension of ulcerative action from soft parts to the bones. Thus the bones of the ear are often affected by ulceration of the cartilage or lining membrane of the meatus; the bones of the palate, from ulceration of the mucous membrane lining it; the bones of joints, from ulceration of the surrounding soft structures. It is very rare for caries to begin as a primary disease, at least in tertiary syphilis. During this ulceration of bone, serious destruction may take place. Joints may be disintegrated, the organs of hearing lost, and the bones of the nose or palate destroyed. The bones of the skull are usually affected in their outer and middle tables only. The diploe becomes filled with bony matter, and then ulcerates or dies. Sometimes, although rarely, the inner table is affected to a greater extent than the outer or middle. Effusion may then take place between the bone and dura mater, and the disease may extend by continuity of action to the brain. The brain may then become affected with red softening, and a part of it be ultimately softened down to the consistence of cream. In these cases it is the surface of the brain which is primarily affected; but in those cases where the brain has been supposed to be affected independently of the bones, some of the central portions, such as the corpora striata, are the parts that have been found softened.

Syphilitic orchitis will be more fully described under the head of diseases of the testicles. The course of the disease is remarkably slow and indolent, lasting for years, unless remedies have been applied; sometimes, as Dr. Wilks has well pointed out, the testicle may atrophy, from absorption of the effused material, and come to resemble a form of cirrhosis—as a firm alveolated-looking fibroid tissue, from the shrinking of the organ, thickening of the tunica albuginea, and the disposition of the atrophied remains of the spermatic ducts, and the fibrous processes from the fibrous investment. The sexual desires are not changed, unless in very chronic cases, or when the state last described has affected both organs.

The deposit usually occurs in the body of the testicle. Circular nodules of a yellowish-white material may be found dispersed through the substance of the organ or collected in one mass. At other times, according to Lancereaux, radiating bands of a tendinous appearance, starting from the thickened tunica albuginea, traverse a part or the whole of the thickness of the organ, insinuate themselves between the seminiferous canaliculi, and compress and separate them one from the other. The organ may then undergo a true fibro-fatty change.

Dr. Lancereaux has, under the head of gummy deposits, given a description of syphilitic affections of a great variety of internal organs. The deposits which he describes are sometimes extensive and comparable to the chronic phlegmasiæ; sometimes limited and circumscribed. These deposits appear in the form of nodules or tubercles, and it is to this condition that the term "gummy tumor" is particularly applied. Dr. Wilks has also given an admirable description of them as they occur in muscles, in the lungs, liver, and spleen, in different parts of the nervous system, and in other internal organs. The limits of this essay preclude the possibility of tracing here the peculiarities which syphilitic disease presents in these different parts.

The absorbent glands are very frequently enlarged in tertiary syphilis. The condition of those situated in the upper and back part of the neck has, by many eminent writers, been regarded as diagnostic of a patient's system being affected with syphilis, or otherwise. But the absorbent glands are generally only affected, in secondary and tertiary syphilis, in consequence of disease in the parts from whence they have their origin. It very frequently indeed happens, both in primary and secondary syphilis, that there is a sore upon some part of the head, and then the posterior cervical glands will be enlarged; but if the sore be confined to one side only (as, for instance, a chronic ulceration on one cheek), then the cervical glands will be enlarged only on that side.

TREATMENT OF TERTIARY SYPHILIS.

The same general remedies are used for this so-called tertiary, as for the secondary forms of syphilis. Patients laboring under tertiary syphilis have, however, often undergone more than one course of mercury, imperfectly administered perhaps, or the effects of which may have been ill-regulated. In the great majority of cases, any further prolonged exhibition of mercury internally is out of the question. Iodide of potassium, sarsaparilla, bark, the mineral acids, and opium, are therefore the remedies most generally used. The iodide of potassium is an excellent remedy in many forms of tertiary syphilitic ulceration, in cases of enlarged glands, and in syphilitic affections of the bones. From three to five [or ten] grains of this medicine three times a day will seldom

fail to relieve the pain of a syphilitic node within a few days.

The benefits of sarsaparilla are most marked in those cases in which the patient's constitution has been debilitated by the abuse of mercury, or where the bones have become affected with caries. In order, however, to obtain the remedial effects of this medicine, it should be given in sufficient quantity; a pint of the decoction should be given daily, or half an ounce of the fluid extract three times a day, and continued for some weeks. The iodide of potassium may very conveniently be combined with any of the preparations of sarsaparilla. Bark, iron, and the mineral acids are all of use in restoring the strength of the patient, impaired either by the disease, or by the injudicious use of remedies; and opium, by relieving pain and giving rest, will often prove most useful. But none of the medicines now mentioned will cure syphilis. Every form of this disease may ultimately be cured by the unassisted powers of nature, and the remedies above mentioned may render much assistance; and some of them, especially the iodide of potassium, have great influence in removing particular symptoms, but they do not cure the disease. The only medicine which can be considered as doing this is mercury; but in the tertiary forms of disease this medicine can scarcely be administered internally, and inunction is apt to be followed by troublesome pustules and ulcerations. Where other means fail, the slow imbibition of calomel through the skin affords an excellent means of introducing the medicine into a patient's constitution. If this remedy is really indicated, there is scarcely any condition in which it may not be used. In consequence of not interfering with the internal organs, it does not in any way increase the weakness under which the patient may be suffering, and may be given as a patient lies in bed. A large class of cases, in which a few years ago mercury was thought altogether inadmissible, are now habitually and effectually treated in this way. In the treatment of tertiary syphilis, the action required is less than in the secondary forms of the disease, but it should be maintained for an equal length of time. Ten grains of calomel used with the fumigating lamp, as described in the next section, are often sufficient; and if there are any open sores, still less may sometimes be used. Any of the usual tonics may of course be administered internally, at the same time that the patient is using mercurial fumigation. If the patient suffers much from perspiration, the calomel may be volatilized with a slight flame without any water. In this way any increase of debility in consequence of the sweating will be avoided. In cases where a patient's constitution has not been impaired, other forms of mercury may occasionally be used.

Some of these have been thought to be peculiarly adapted to one kind of affection, and some to another. Thus, for iritis calomel has generally been given internally, combined with opium. For the deep ulcer of the tonsils the bichloride of mercury has very often been prescribed; and for eruptions on the skin the proto-iodide of mercury has been most extensively employed. But, generally speaking, whatever may be done with these remedies, may also be effected by the imbibition of mercury through the skin; and the adoption of this mode of treatment, when properly carried out, is attended with a great saving of the powers of the patient's constitution.

[The indolent nodules formed of plastic material, described by the author, are to-day best recognized under the title of gummata, already named in these notes. Occurring in the nasal passages, their degeneration is accompanied by the fetid forms of ozæna, and may terminate in deep ulceration, necrosis and exfoliation of thin lamellæ of bone, breaking down of the bridge of the nose, and characteristic permanent deformity. The history of the development and involution of gummata is practically the same in all portions of the body, the accidents of site determining the clinical differences in each case. Thus in the larynx, there may be stenosis from gummatous hyperplasia; true membranoid occlusion leading to aphonia, dyspnœa, and even fatal suffocation; or ulcerative destruction of portions of the epiglottis, pharynx, vocal cords, perichondrium, and cartilages. Fibrous forms of pulmonary syphilis, more often hereditary, may be characterized by hyperplasia of the interlobular connective tissue and complicated by pleuritic or bronchial inflammatory processes: while the ulcerative or degenerating varieties are accompanied by many of the signs of pulmonary phthisis, such as fever, hæmoptysis, and progressive emaciation. But in these cases, a diagnosis can be usually established by localizing the lesion, by ascertaining the facts as to syphilis, and by the results of specific treatment, which are often brilliantly successful.

Lingual gummata may occur upon the dorsum of the organ, immediately beneath the mucous surface, or be deeply imbedded in the muscles. They leave indurated irregular ulcers whose long diameter is usually in the axis of the tongue, with foul base and raised adherent borders. As distinguished from epitheliomata in this region, they form in earlier periods of life; are not rarely multiple; and, as a rule, are

unaccompanied by pain, discharge, hemorrhage, or serious disturbance of function.

Submucous hyperplasia of connective tissue constitutes the so-called ano-rectal syphiloma, whose evolution and subsequent contraction result in stenosis of the gut. The induration in this part suggests the presence of a dense semi-elastic cylindrical mass beneath the membrane. Common sequelæ are ulceration, fistulous sinuses, and variable discharge. In the treatment of these and the similar œsophageal stenoses, the introduction of bougies, graduated as to size and occasionally medicated, is often requisite in connection with appropriate internal therapy. They may be employed at intervals, or where admissible, continuously. It may well be doubted whether the iodide of potassium, of such efficacy in tertiary syphilitic manifestations, is capable of exerting much influence upon these membranoid or semi-membranoid occlusions of the outlets of the body.

Gummata occur also, not only in the pericardium, but as exciting causes of a syphilitic parenchymatous myocarditis in the wall of the left ventricle. Similar gelatiniform masses have been discovered by Lancereaux in the arteries; and also a diffuse thickening of the coats of the vessels, tending to occlusion of the lumen. These lesions, affecting the smaller arteries of the brain, may occasion apoplectic and epileptiform seizures, as late symptoms of lues. Other symptoms of brain syphilis are: intense cephalalgia, vertigo, aphasia, hemiplegia, and strabismus. Balfour[1] points to the significance of coexisting facial neuralgia with paralysis of the ocular muscles—two or more of the latter being selected for implication with an apparent capriciousness which is characteristic of syphilitic lesions. It should not be forgotten that intra-cranial bone lesions (nodes, gummata); pachymeningitis from hyperplasia of connective tissue, resulting in sclerosed patches of the membranes and adjacent substance; gummata of the meninges; and even true encephalitis from neoplastic masses in the cerebral substance, may lie at the foundation of the often obscure symptoms whose origin demands recognition. When the spinal cord is involved, the pathological processes are not different, and may be limited to the membranes, or medulla. Paraplegia and locomotor ataxia are the usual clinical results. In the former, the stumbling and unsteady patient complains of a sense of abdominal constriction, has but partial control over bowel and bladder, and under the most energetic treatment is liable to suffer from relapses. In our experience both forms occur chiefly in cases long untreated or unrecognized, and an unrecognized is usually an untreated disease.

The special signs of syphilitic involvement of the organs of sight and hearing are described in another part of this treatise. It should be stated, however, that syphilis of the nervous system finds expression in many lesions of the optic and auditory nerves, as also of the nerves which supply the apparatus accessory to the eye and ear.

The renal diseases caused by syphilis may be induced by hyperplastic, gummatous, or degenerative changes. Albuminuria, with casts demonstrable by the microscope, has been noted in several instances; and, although suspected to be due to the ingestion of iodide of potassium, has been successfully treated by ourselves with that remedy. Besides the syphilitic affections of the testis, named by the author, should be mentioned the epididymitis affecting the head and body of the organ, usually occurring in the earlier periods of the disease, degenerating gummata with sequelæ suggestive of benign forms of fungus of the testicle, and impotence depending on both functional and structural causes. In women, gummata and diffuse infiltrations of the substance of the mamma occur as rare phenomena; while functional disturbance of menstruation, abortion, miscarriage, and disfiguring granulation-cell proliferation of the placenta,[1] are sufficiently common.]

XII. Administration of Mercury.

Three different ways of giving mercury have been recommended. 1. The administration of the medicine internally. 2. Its introduction into the patient's system through the skin, by means of mercurial frictions. 3. The use of mercurial vapor baths.

1. The blue pill is one of the most ordinary forms in which mercury is given. From three to five grains, combined with half a grain or a grain of opium, may be ordered two or three times a day. The hydrargyrum cum cretâ may be given in doses of from three to five grains, either alone or with an equal quantity of Dover's powder.

Calomel, either alone or mixed with opium, or in the form of the red pill, may also be given in doses of from one to three grains two or three times a day. All these preparations of mercury, as well as those which have been previously mentioned, are very valuable remedies under certain circumstances. But where a sustained and continued action is required,

[1] Edinburgh Med. Journal, Oct., 1875, p. 289.

[1] Frænkel. Archiv f. Gynæk., vol. v., 1873, p. 45.

they are very apt to produce irritation of the digestive organs. Even when combined with opium, the internal use of mercury can seldom be continued as long as is desirable. It will be found in some way or other to affect the patients' constitutions injuriously, and to make it extremely distasteful for them to continue the course for a proper and necessary time.

Mercury introduced into the stomach and intestines produces, as is well known, a powerful effect upon the liver. This doubtless depends upon the blood from these parts being directly conveyed through the vena portæ to that organ. Sir Ranald Martin, in his admirable work on the influence of tropical climates, observes, that mercury enters into intimate union with the elements of the blood, and that it must therefore modify its plasticity, and influence all the organic functions to which it is subservient. The parts upon which this influence expends itself, when mercury is given internally, are the liver[1] and intestines. Even robust and healthy persons can seldom bear any prolonged irritation of these organs with impunity; and in patients of relaxed enfeebled habits, any sustained mercurial action which produces its primary and direct influence upon those parts is quite out of the question as a remedial measure.

2. Mercurial inunction is a very efficient way of using mercury; but is dirty, laborious, and often little suited to the taste of those who require its use. On this account, the patients very frequently apply the remedy with great irregularity, or even omit it altogether. It is, however, much less liable to produce griping and purging than when the drug is given internally, and the effect upon the constitution is not nearly so debilitating. When mercurial ointment is used, half a drachm or a drachm is rubbed into the inside of the thighs by the patient every night. This in winter is conveniently done before a fire. The ointment should be rubbed in until it disappears. The process will occupy about half an hour, and the patient should wear some flannel drawers, and not wash the remains of the ointment off. The application of the ointment must be repeated every night until the gums become soft and slightly spongy; this is the best indication of the proper action of mercury upon the patient's system, and the action should be maintained by regulating the quantity of ointment used, for six, seven, or eight weeks, according to circumstances. Many surgeons are in the habit of leaving off the mercury soon after the patient's gums are affected. According to the author's experience, this practice not only fails to cure the disease but actually does harm. The patient's constitution is weakened to a certain extent, and the disease is not cured; but what is of more importance still is, that the secondary symptoms, when they do appear, are often of a worse and more intractable character than if no mercury had been given.

There are two principal objects in view in treating a case of syphilis; the first is to remove the symptoms, and the second to cure the disease. Now a short course of mercury will often effect the former of these two objects, as will also, in almost all secondary cases, the iodide of potassium; but neither the short course of mercury, nor the iodide of potassium, will in general cure syphilis. The symptoms will, it is true, be removed, but they will return; and practically it is found extremely difficult to induce patients, particularly in the upper classes of society, to continue a course of mercurial inunction sufficiently long to prevent the occurrence or the return of secondary syphilis.

By introducing mercury into a patient's constitution by inunction, its deleterious action upon internal organs is avoided. The amount absorbed into the blood produces its influence equally throughout the system, and is not conveyed direct to the liver, as when the medicine is administered internally.

But great as the advantages of the inunction of mercury are as compared with its internal administration, it nevertheless is attended with certain inconveniences which prevent its very general use. The inunction of mercurial ointment, so as to insure the proper effect of the remedy, requires considerable labor and perseverance on the part of the patients, and it is with difficulty that they can be induced to continue its use for any length of time; and sometimes it produces a troublesome pustular eruption on the skin.

3. Fumigation of the surface of the body by means of certain mercurial preparations possesses the advantages of inunction, without some of the objections to which this is liable. But, like other modes of using mercury, it was tried in a variety of ways before a safe and efficient mode of administration was adopted.

In the years 1786–7, Mr. Pearson had a fumigating machine constructed according to the directions given by M. Lalouette. This apparatus, although it was thought to be new at the time, differed in no material respect from that described by Nicholas de Blegny in the year 1683.

Mr. Pearson made a considerable num-

[1] A case has recently fallen under my observation in which a young gentleman, after the prolonged use of mercury internally, died of jaundice, to the surprise of all his friends.

ber of experiments with this fumigating machine, and found that the gums became turgid and tender very quickly, and that the local appearances were sooner removed than by the other modes of introducing mercury into the system. But, to counterbalance these advantages, it was found that the mode of treatment adopted induced debility, and that ptyalism was often excited rapidly, and at an early period. Mr. Pearson found that he was consequently obliged often to discontinue his course of treatment.

Sir Benjamin Brodie's experience coincided with that of Mr. Pearson. He found that it was difficult to regulate the mercurial action ; and he observes that by using mercurial fumigation "you may affect the system too much or too little ; and you may be taken unawares by the patient's gums becoming all at once excessively sore."[1]

From observations and comparative experiments which I made during the years 1855-6, I feel satisfied that the irregular results noticed by Mr. Pearson and Sir Benjamin Brodie, depended upon the difference in the chemical composition of the powder used for the purpose of fumigation, both before and after it was raised into a state of vapor. The gray oxide of mercury (the preparation generally used) varies much in color as obtained at different shops. Some specimens will not volatilize at the temperature produced by an ordinary spirit-lamp under a metallic plate. Other specimens of a lighter color volatilize quickly enough. When the darker specimens are sublimed, they are decomposed in a greater or less degree. A deutoxide of mercury is formed by the addition of an equivalent of oxygen from the air ; and if the temperature be much increased, then the oxygen is driven off altogether, and metallic mercury is sublimed. Under these circumstances, with a mercurial preparation of uncertain composition, and undergoing different changes according to the degree of heat applied, there is no wonder that very different effects should have been produced in different cases. With some samples of the gray oxide it is necessary to use a considerable quantity of the powder in order to insure any effect ; with other samples, a similar quantity produces much more action than is desirable. The gray color of the powder depends upon the admixture of a certain proportion of calomel with the protoxide, and the temperature at which any particular specimen will volatilize will depend upon the relative proportions of the two. The bisulphuret of mercury, again, which has been extensively used for the purpose of fumigation, gives off, when exposed to heat, a vapor, probably the sulphurous acid gas, which has sometimes caused very considerable irritation of the lungs ; and all forms of mercurial fumigation have, in consequence, by some, been condemned.

Now, all the inconveniences above mentioned may be avoided with certainty, by using a mercurial preparation which is always of the same chemical composition, which does not irritate the lungs, and which is not liable to be altered by an increase of temperature. Such a preparation is calomel. We have here a definite chemical compound. It is altered in composition neither by heat nor by moisture, and when used for the purpose of general fumigation may be relied upon to produce its action as certainly as any medicine administered internally. A very small quantity (as compared with the other mercurial preparations) will insure the required effect, and this may be regulated and controlled with great precision.

General calomel fumigation may be used in cases where the administration of mercury by other methods is inadmissible. On account of the small amount of calomel required, it may be used, sometimes with the greatest benefit, even where other modes of fumigation, requiring larger quantities of mercury, cannot be borne.

Calomel appears to have been formerly used for the purposes of general fumigation, as well as other preparations of mercury. But it was used in the same quantities as those other preparations, and was, therefore, open to some of the same objections as they are.

M. Rapou published in Paris, in 1824, two volumes on Fumigations as employed in various diseases. The mercurial preparations which he recommended were cinnabar, Lalouette's mercurial powder (which consisted of a mixture of mercury and clay), calomel, and corrosive sublimate.

The quantity used for the first three, he recommended to be from "a quarter to half an ounce each time." The amount of the corrosive sublimate, he says, should not exceed five or six grains.

Even with these very large quantities, M. Rapou had only seen salivation produced in three instances, and these were of a very short continuance, and yielded to the use of ordinary baths. M. Rapou recommended the mercurial fumigations to be used with steam, which, he said, calmed the system, softened the skin, and did not prevent the absorption of the mercury.

Mr. Langston Parker recommends an apparatus, for the use of which the patient is placed on a chair, and covered with an oil-cloth lined with flannel, which is sup-

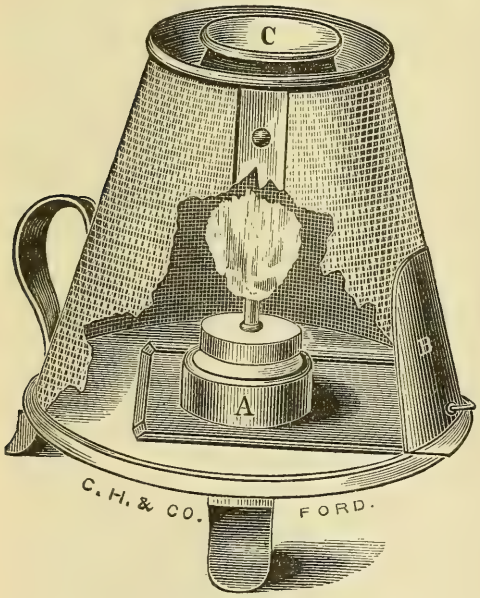
[1] Lectures on Pathology and Surgery, p. 246.

ported by a proper framework. Under the chair are placed a copper bath containing from half a pint to a pint of water, and a tinned iron plate, on which is put from one to three drachms of the bisulphuret of mercury, or the same quantity of the gray oxide, or the binoxide, or other mercurial preparation; under each of these is a spirit lamp.

Now, all the methods of applying mercurial fumigation above mentioned required the use of a complicated apparatus, which private individuals cannot command. In order to adapt this method to general use, it was necessary so to modify the apparatus that any one could use it in his own room; and this has now been most effectually accomplished.

The most convenient calomel vapor-bath, and that which is now generally used, is one which was made at my request by Mr. Blaise. In this apparatus the lamp which sublimes the calomel boils the water at the same time. In the centre of the top, immediately over the wick of the lamp, is a small, separate, circular tin

Fig. 26.



Lamp for calomel vapor-bath.

plate, upon which the calomel is placed. Around this is a circular depression, which may be one-third filled with boiling water. The apparatus is then placed on the ground, and the lamp is lighted. The patient sits over it, with an American cloth cloak, or a Mackintosh, or a moleskin cloak fastened around his neck. He thus becomes surrounded by calomel vapor, which he is generally directed to inhale for two or three separate minutes during each bath. In doing this the patient should not put his head under the cloak, but simply allow some of the vapor to escape from its upper part, and breathe it mixed with a large proportion of common air. At the expiration of a quarter of an hour or twenty minutes the calomel is volatilized and the water has boiled away. A portion of the calomel is deposited, together with the condensed vapor of the steam, on the patient's body, and is there to be left. The quantity of spirits of wine used upon each occasion is so regulated that the lamp goes out of its own accord about the same time as the calomel disappears. The patient then gradually unfastens the cloak, and in about a minute he is sufficiently cool to put his night dress on without much interfering with the very fine layer of calomel which covers his body. He must be particularly told not to wipe his skin, as by so doing he would necessarily interfere with the action of the medicine. Should there be no objection on the part of the patient, he may go to bed in the cloak and sleep in it either for a part or the whole of the night.

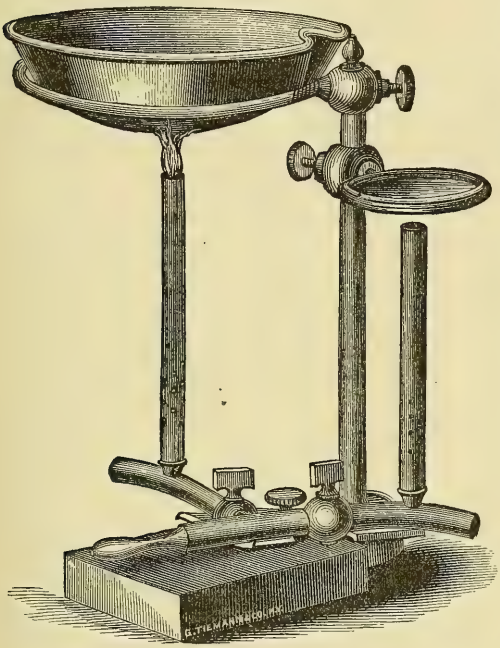
Of all the modes of administering mercury, fumigation is that which is attended with the least demand upon the patient's constitution. The amount administered in this way can be regulated with the greatest facility; and the action may be maintained without inconvenience for almost any length of time. On this account, as well as for other reasons, fumigation is, in my opinion, less liable to be followed by the recurrence of secondary symptoms than any other mode of treatment whatever; and of all the kinds of mercurial fumigation, that by calomel is the safest and the most convenient, if not the most efficacious. The imbibition of the medicine through the skin prevents its injurious action upon internal parts; while the comparatively small quantity used, although quite sufficient to produce any amount of action that may be required, insures the patient against any sudden or violent effects.

In this mode of using mercury, the whole of the skin may act as an absorbing surface; and, when requisite, the effect may be still further increased by absorption from the mucous membrane of the nose, mouth, and bronchial tubes.

In secondary syphilitic disease, the surface of the body and the mucous membranes are peculiarly liable to be affected; and the process of fumigation has here this great advantage, that the remedy is applied directly to the diseased parts, and acts immediately upon them. When administered internally, it has, on the

contrary, first to be absorbed into the blood, and carried the round of the circulation, perhaps more than once, before it comes into contact with the affected structures. Many old and intractable syphilitic ulcerations yield with surprising rapidity to local calomel fumigation; and there is no reason why the same principle should not be taken advantage of in treating the more general forms of the disease.

[Fig. 27.



Maury's apparatus for moist mercurial fumigation. It consists of two Bunsen burners, one surmounted by a pan to contain the water, the other by a small shallow dish for the mercurial. By means of a flexible tube, the apparatus may be connected with any ordinary gas-fixture.]

Calomel alone, without the vapor of water, may be used, especially where the local action of the medicine alone is required. But, from a series of comparative trials which were made in the early part of the year 1856, it became evident that, for the purposes of fumigation, it was advisable that a small amount of the vapor of water should be present. In the process of sublimation some free hydrochloric acid is given off, and the vapor of water so far dilutes this as to prevent its irritating the lungs.

The syphilitic poison, in a very great majority of cases, produces its principal effect upon the skin. Through this organ, nature attempts its elimination; and a free secretion from the skin assists the action which nature has already commenced. It appears, from an extensive trial, that not only is the poison eliminated from the system more effectually where there is a free cutaneous action, but that under this condition the internal organs of the body are much less likely to be affected by the disease than under other circumstances. The calomel vapor-bath combines the various advantages now alluded to, and its great practical advantage is attributable: 1. To the small quantity of mercury which is required, when used in this way, in order to produce the requisite effect. 2. To the fact that the imbibition of the medicine through the skin leaves the digestive organs unirritated and the digestion unimpaired. 3. To the circumstance that there is something in the free secretion from the skin, which the combination of steam and calomel produces, that moderates and controls the mercurial action, and at the same time determines the secondary syphilitic action to the surface of the body rather than to internal organs.

The action of the calomel bath should generally be continued until all syphilitic symptoms have disappeared, and for a week or two afterwards. During the first few weeks, the patient should not be subject to the influence of much fresh air, or to cold water, and when practicable should remain in the house. The bath should be given every night, and its effects may be regulated either by the quantity of calomel used upon each occasion, or by the amount of vapor which is inhaled. Within the first few days a slight tenderness, redness, and swelling of the gums will indicate the mercurial action. This condition should, if possible, be sustained during the whole of the course; but it is not necessary to produce at any time a greater effect.

The length of time during which this action is to be maintained must vary considerably with individual cases; a first course should seldom be less than from two to three months.

The calomel vapor bath in its present form, introduced by the author in 1857, may now be said to have come into general use. One instrument maker, Mr. Blaise, has sold upwards of 2700 lamps for the purpose.

Local calomel fumigation.—But whilst the use of calomel fumigation over the whole body and with a view of producing a constitutional effect is so beneficial, its local employment is not less advantageous. Scarcely any case of local syphilitic disease occurs which cannot be benefited in a marked degree by it. And

whatever objections there are to its becoming of extensive application, they do not arise from any want of success in the treatment, but from a difficulty in obtaining proper apparatus.

Different kinds of apparatus have been used for local fumigation. The calomel-fumigating lamp previously described answers the purpose extremely well. The vapor of calomel, being of very light specific gravity, ascends, and any part placed over it becomes coated with a very fine layer of calomel. This forms an excellent dressing for intractable ulcers, whether of a primary or secondary nature. Tubes of various shapes have also been employed so as to direct the vapor of the calomel to particular parts. Thus, a long tube has been adapted to the calomel-lamp with a mouthpiece, for the purpose of inhalation in affections of the throat. A roll of paper has been often used with the same object. But it is evident that, as the calomel mixes with the air, the simple act of respiration does all that is required; and as far as the throat is concerned, any tube is much more likely to detain the calomel, than to direct its course. It is often, however, convenient to direct the vapor of calomel to parts which cannot well be brought over an ordinary lamp, and then an additional apparatus is necessary.

A reference has already been made to the inhalation of the mercurial vapor for the purpose of accelerating its constitutional effect, but in all cases of secondary sore throat, particularly those in which iodide of potassium fails to effect a cure, the inhalation by its local influence is exceedingly beneficial. The inhalation may be effected in the manner already described, or if for other reasons it is unnecessary or inconvenient to use the general bath, an apparatus similar to a steam inhaler, but provided with a lamp and basin for the calomel and water, may be employed. Such inhalation should not be continued for any length of time, unless a constitutional result be desired. Four grains of calomel once or twice a day will generally be found sufficient to remove the disease.

In cases of primary sores on the penis, an apparatus provided with a tube capable of containing the whole organ is convenient. The use of the instrument may in these instances be continued sometimes for twenty minutes or more, and may be repeated daily, or even more frequently, till the sore is healed, or at least furnishes a healthy innocuous secretion.

In cases of suppurating bubo another form of apparatus must be employed. The instrument must be furnished with a tube expanded into a funnel-shaped termination, and when in use a piece of Macintosh should be wrapped round the instrument inclosing a space large enough to contain the whole of the diseased surfaces. The Macintosh, by its flexibility and facility for adaptation to irregular surfaces, effectually retains the vapor in contact with the skin as long as may be necessary.

In some instances it is desirable to use local calomel fumigation to the arms and legs, and as the extremities are more easily isolated from the rest of the body, the employment of apparatus is attended with less inconvenience. A simple modification of an arm or hip bath is alone sufficient.

There is little danger of pushing the remedy in this kind of exhibition far enough to produce a direct constitutional effect. Generally improvement is so rapid that as the course of fumigation continues, its employment becomes less frequent until it is omitted altogether.

[In considering the treatment of syphilis it is necessary to remember the distinction, recognizable in practice, between benignant and malignant cases. Many patients, untreated during years of infection, exhibit trifling symptoms. The questions relating to the hygienic management of the disease, especially including care of the teeth, mouth, skin, and ano-genital outlets, are of prime importance, but scarcely to be discussed in these limits. The necessity of a tonic regimen, often to the exclusion of so-called "specific" treatment, is frequently imperative. The largest experience has served only to increase the confidence with which reliance is placed upon mercury and iodine in the treatment of syphilis, and to throw into increasing disfavor the vegetable remedies vaunted as efficient, such as guaiacum, sarsaparilla, cundurango, and tayuya. Beside the methods of employing mercury named by Mr. Lee, may be mentioned subcutaneous injection, lately popularized by Lewin, of Berlin, and increasingly employed in hospitals where the patient is completely at the disposal of the surgeon. The use of the pills of the mercuric protiodide by the stomach, in the manner described by Keyes as the "tonic method," is justly popular when it is desired to suspend mercurial fumigation and to substitute for it a more convenient routine. By this method there is a very gradual increase of the dose of the metal, an additional pill being swallowed every third or fourth day, till slight effects are produced (looseness of the bowels, slight dental tenderness) when the dose is promptly reduced one-half. This last is called the "tonic dose," and may be continued with advantage for long periods of time, observations with the hématimètre showing that during such periods there is an actual increase in the number of the red blood-corpuscles.

The substitution of the iodide of potassium for mercury, as the disease advances, is followed by benefits now universally recognized. Whether given together in the so-called "mixed" treatment, administered separately, or exhibited in rare or frequent alternation, it should not be forgotten that for the removal of late lesions, nodes, gummata, and tertiary infiltrations, larger doses of the iodide are often requisite than those declared to be officinal. Half-drachm, and even drachm doses will at times clear up a case of hemiplegia, amaurosis, or aphasia, when smaller quantities of the drug seem powerless. Balneotherapy, as practised in Europe and America, is at the best but auxiliary to efficient treatment of other nature. Such treatment must be prolonged for a term of years, with faithful perseverance, to be worthy of the name or to be crowned with a success which cannot be questioned, viz., the radical cure of syphilis.]

TUMORS AND CANCER.

By Sir James Paget, F.R.S. (1860), and C. H. Moore, Esq. (1869).

Revised by Morris Longstreth, M.D.

The natural history of new growths in the human body has of late years been the subject of much research. Virchow, especially, and many contributors in this country to the Transactions of the Pathological and other societies have extended our knowledge of it. But a complete description of these diseases is not even yet possible. However desirable for its scientific interest or for the improvement of treatment, material is still wanting for so full an account of them as would include their varieties, construction, and chemical composition, their intrinsic changes of increase, propagation, and decay, their influence on surrounding parts and on the system at large, and their many causes. On some points, as on the etiology, there is almost everything to learn; the classification and nomenclature of the several growths are at the moment uncertain and transitional; and, with a consideration rather for convenience than for science, certain overgrowths, which are allied to tumors but do not adopt their form, are arbitrarily excluded from that great surgical group of diseases. Accordingly the scope of the present essay is limited as well by the positive knowledge of the times as by the particular object of Surgery.

To the many diseases comprised under the title, Tumors and Cancer, both sexes, all ages, and almost every region of the body are liable. While possessing many characters in common, these growths have yet most important practical distinctions among themselves. They are all additions to the substance of the organ from which they arise, and they consequently present themselves to first view as distorting its proportions. In most various degrees they also deviate from the construction of their parent texture, but with the unvarying effect of contributing nothing to the performance of its function. When once begun, they pursue a mode of life peculiar to themselves; they grow or cease to grow independently of the regulating forces in the part from which they deviate, as well as of the increase, the wasting, or the ordinary maintenance of the rest of the body, and they pass through changes of their own which are unknown in healthy structures. Some of them are isolated by investing layers of tissue, which strictly divide between the perfect actions of the normal organ and the morbid processes within the tumor; whilst others, not so limited, induce continuously their own disease in the surrounding natural parts. Most of them occur singly in the body, but sometimes they are multiple, in which case they may be either alike or of different kinds. When unlike, they are independent of one another, whether occurring in separate parts or even in the same organ; but if there be more than one of the same nature, they arise with so much connection as to be restricted to a common region, or to similar though separate tissues, or there is an order in their successive development which shows the later to be dependent on the first. Surgical operations bring out marked differences in tumors, of which

some show no tendency to return, whilst others, though operated on in the same manner, recur again and again. With this tendency to local recurrence there may also, or may not, be combined an original capacity of the growth to propagate itself in other distant and dissimilar parts of the body.

The distinction thus broadly indicated was of old expressed in the words tumor and cancer. In the theories of former times, interpreting such different clinical issues, it was assumed that the growths were of wholly different nature and origin, and the same difference was implied in the division of them into the *innocent* and the *malignant*. The one term expressed harmlessness if the tumor were left, and curability if it were excised; the other the converse of these propositions. Moreover, from the frequent return of the latter tumors after operation, and from their eventually implicating the system at large, a reflection upon their original nature came to be included in the epithet malignant, to indicate that they distinctively had a constitutional source. Modern opinion tends far away from assigning such malignant characters exclusively to the cancers. A great distinction must still be maintained between the various tumors, but with their substantial unity they cannot be wholly studied apart.

The classification of new growths by their anatomical characters would certainly be the most satisfactory, both in explanation of the source, and as presaging the result of any tumor, if only its clinical progress were deducible from its texture. But, in fact, there is much overlapping of the qualities of different new growths, and between tumors and cancer especially, previously recognized distinctions become more and more obliterated by the extension of clinical and microscopic study. Indeed scarcely any, if any, single ground exists on which they could be decisively distinguished from one another. On the one hand, tumors (as the cutaneous) may be hereditary, may persistently increase (as do some of the fibro-cellular) without any apparent limit of growth, may recur (as the fatty) after threefold or fourfold incision, may be repeated (as the cartilaginous and cysto-cartilaginous) in organs apart from that in which the primary tumor arose, may (as the fibroid and cysto-sarcomatous) degenerate in texture while augmenting in rate of growth in the course of repeated local reproductions, or may prove fatal. Cancer, on the other hand, may be true cancer, and yet devoid of any of these characters.

Some instances may illustrate the qualities possessed in common by innocent tumors and malignant cancers. Most of the former are single; the latter, though single originally, are usually numerous at the time of death, and scattered in different parts of the body. But there are cancers, as in the rectum and mamma, which remain single to the end of life; and there are tumors of the innocent kind which multiply. For instance, it is usual to regard a cartilaginous tumor as innocent; yet Paget and Otto von Weber have recorded examples in which a tumor strictly cartilaginous underwent dispersion in the body, and multiple secondary cartilaginous tumors formed in internal organs, which naturally contain no cartilage. By Mr. Paget the source of the pulmonary tumors was demonstrated; the primary disease in the testicle having, in the manner of cancer, first infected the glands, from which a protruding enchondroma opened within the inferior vena cava, and doubtless shed fragments into the blood ascending to the lungs. In the same way I have found uterine veins filled with soft epithelial growths which were identical in external and in microscopic appearance with multitudes of tumors scattered through the liver and the lungs. As the veins of the uterus pass into both the portal and the cava, whilst those of the testicle belong to the cava only, a mechanical conveyance of the respective new growths to the corresponding organs is manifest, and no difference in the natures of enchondroma and cancer can be drawn from their dissemination. Even the most virulent of the cancers spreads in the same way.

A man, having lost his eyeball, came into the Middlesex Hospital with a vast bleeding mass of soft cancer protruding from the orbit. On inspecting the globe of the eye with the tumor which had previously been removed, the recurrence was explained by the discovery of cancerous elements in the optic nerve up to the very point at which it had been divided in the operation. By a combined use of the knife, cautery, and caustic, Mr. De Morgan extirpated the whole contents of the orbit; the wound cicatrized, and the man was healthy for more than a year, but in the second year he died with palsy of the lower extremities. It was then found that a third medullary tumor had formed on the stump of the same optic nerve, within the base of the skull, and that far off from it, within the spinal arachnoid, there were similar tumors of much smaller size adhering upon the point of the spinal cord and the roots of the lumbar and sacral nerves. Recurrence by continuity, as distinguished from constitutional reproduction, was clear in the three optic tumors; and the peculiar position of the spinal tumors, together with the date and progress of the symptoms, showed those tumors to be but detached fragments of that within the skull, which had sunk in the fluid of the arachnoid,

and had adhered and grown at its lower part. A few glands were found cancerous behind the arch of the aorta, but there was no disease in any internal organ from which a general tendency to cancer could be inferred.

Such recurrence after operation, which is characteristic in cancer, may be paralleled in growths so simple that no one ascribes to them any malignity. Not to mention the importance of wholly extirpating cysts, I may refer to Mr. Curling's specimen of fatty tumor four times recurrent, in which Mr. De Morgan and Mr. Hulke ascertained that a fragment, composed of young and growing fibrous tissue, had been left in the wound. Thus in recurrence and in mechanical dispersion different tumors are alike.

The *source* of new growths is the natural textures. Some tumors obviously are extravagant and disorderly overgrowths of normal parts, as when the fang of a tooth exceeds by four or five times the size of the tooth itself. Whether deviating little or much, therefore, from the parent texture, tumors bear traces of that element of an organ in which they originated. Each texture would thus appear to have its own tumor, and cell, fibre, and nucleus respectively be capable, like an ovum, of overgrowth. Hence, on the one hand, wholly different new growths, both innocent and malignant, may coexist in separate tissues or organs of the same person; and, on the other hand, there occur no inconsequent developments, as of brain into bone, or of skin from an exostosis. The tumors arising in similar organs are alike. This rule applies not only to parallel organs, as a right mamma and a left, but to those also of separate persons, when one is but rudimental. Thus scirrhous, or cystic, or fibroplastic disease presents the same character, whether it occur in the female mamma or the male mammilla; the prostate has its fibro-muscular tumor equally with its homologue, the uterus; and there is correspondence in the tumors of the testicle and the ovary. There are, however, tumors which do not resemble any part of the organ in which they lie. Of such it may be said, that a tumor unlike its seat comes from elsewhere. And this in one of two ways. Either it originates in a structure proper to one region, but dislocated into another during growth, of which there is an instance in the cartilage capping an exostosis of the shaft of the femur or tibia near the knee; or it has escaped from a kindred morbid growth, and has travelled and rooted itself in a different soil. Cystic tumors growing in the lungs after castration of a cystic testicle, melanotic masses staining halves of organs by pigment derived from a black tumor of the skin, or scirrhus from a cancerous mamma appearing in the compact part of a femur, are some of many examples of foreign and transplanted tumors. It should be added that changes within a tumor in the course of growth or degeneration may obliterate almost every trace of its first textural character, and that in some rare instances the same effect may be more completely produced by the supervention of cancer in a tumor originally of a different nature.

Of all questions relating to tumors, the *causes* are perhaps the least known. They are numerous, and more so perhaps than even the growths themselves. Either they operate primarily in the texture which is the source of the tumor, or they are such as can act upon it. Tumors thus severally caused might therefore be named *spontaneous* or *induced*. A cyst, for instance, would arise from one or the other of such causes, according as it depended on altered osmosis through its walls, or on obstruction of an excretory duct. But in the production of tumors a more important distinction must be recognized according as they result from an *external* cause, or from one within the body, which *internal* one may be either *distal* or *intrinsic*. Tumors are traceable to an external cause, when it directly produces overgrowth of one or more of the suffering textures. In this manner pressure leads to the formation of a bursa, that is, of a hypertrophied and condensed state of all the parts pressed on, and the permanent maintenance of fluid within them, with possibly a fibrous tumor. And in this manner also may a growth of the natural connective tissue of the cerebral substance into a "glioma-tous" tumor be accounted for, a rough bony projection into the substance of the brain beneath an old fracture of the skull inducing overgrowth by the ceaseless movements of the hemisphere against it at every pulse and respiration.

The production of tumors by a cause which influences the misgrowing texture from within is less easy to approach. Much must here be assigned to the original power of each part of the body to outgrow its proportion to the adjacent parts, and to multiply indefinitely, as do bosses of wood on the trunks of trees, when once it has escaped from the usual neighborly restraints. Considering, however, the great activity put forth by some of the natural organs in the fulfilment of their functions, and still more the energy of the ovum, it is not difficult to understand the power residing in textures, when misdirected, to form textural tumors. Spontaneous overgrowth sometimes presents itself in a rapid development of epithelioma, when local efforts toward the healing of an open wound have continued for a long time, and have been unsuccessful; or when in

a mole, or near a scar, or at any region where dissimilar tissues in close contact act and react upon one another, cancer at length springs up. Such causes may be called local internal, or intrinsic causes. There appear to be others also which are internal, but which depend on a more profound relationship of organs and textures to one another, and even act from a distance on the part in which the tumor grows. This last provocation of one organ to morbid growing by another organ remote from it, is conceivable only as reflected through nerves, and is deducible only from clinical evidence. The influence of nerves upon textures is illustrated in many ways; sometimes in the nutritive decay of an organ ill supported by nervous force, and oftener perhaps, as in the stringed pustules of herpes zoster, by inflammatory changes. The neuromas which cluster along a nerve, or the fatty tumors forming in a single limb, might well be traced to such a cause, and indeed Van der Kolk once concluded respecting a cancerous tumor that it was due to nervous influence. That which is true of direct nervous excitement of a texture is likely to be equally true of an incitement reflected on it. Nerves respond to distant irritation with remarkable precision, and as by their intervention organs remote from one another do mutually control and adapt their normal functions, so are the nerves capable of propagating a morbid influence. The well-known effect, for instance, of gastric disturbance upon the mouth suggests the order of causation of such of the epithelial cancers of the tongue, fauces, and lips as have not a local origin; but the influence of the uterus over the breast is the most prominent instance, both of the normal control of one organ over another, and of the source of some mammary tumors, including cancers, in prolonged uterine ailment. Nerves indeed furnish the only means by which moral feeling and emotions can exercise their acknowledged influence over the tissues, whether to suppress or excite a secretion, or to call up, as in the instance of grief, a morbid growth. Of other once reputed causes, for instance, of a constitutional origin particularly of cancer, none now command the general opinion, which is rather led in the estimation of them by more and more extensive physical research.

The liability to new growths is partly determined by *age*. Some arise during the development of organs, but many more in the period of their involution. The tumors then usually differ in nature with the state of the organ at the time of their formation. Those are the most active which begin during growth; in completed organs they are, as a rule, slower but still innocent; while the malignant belong to parts of which the functions are waning. There are occasional exceptions to these usual rules. Thus Mr. Nunn recently had in his practice a case of ordinary but rather rapid epithelioma of the lip and cervical glands at so early an age as twenty-five; and, on the contrary, I removed a very large cystosarcoma of five years' growth with the breast of a woman aged seventy-five. The rule of *sex* appears to be more decisive than that of age. With greater functional capacity the female generative organs are more exposed to tumors than those of the male sex, and indeed so excessive is this liability that women present many more tumors of both kinds than men, although particular growths, and especially cutaneous cancers, are more numerous in the male sex.

In the *composition* of a grown tumor there are parts which are accidental, as well as those which are essential. Blood and various pigments and liquids are sometimes superadded to the original tumor, and assume by their color and other effects an undue importance. The essential parts of the tumor are the living and active. The decaying part or the dead may accumulate in it, or be harmlessly eliminated, but by the living part increase of the tumor takes place, sometimes interstitially, as in the soft cancers, sometimes on the exterior only, as in the rodent, and sometimes by a wavelike advance and return of growth, as in scirrhus. This part alone maintains the original character of the tumor, both while remaining in its primary seat, and when disseminated. The difference here indicated is shown in some innocent tumors, as well as in the cancers. Either may shed mere used-up surplusage or their own living elements. From the skin of a toothed mole within an ovarian cyst there were shed in ten years into the cavity of the cyst seven pounds in weight of epithelium and hair. Probably no change took place in this stuff after it had been cast; it lay harmless in the cyst, and only accumulating. But besides this refuse matter within the cyst, there were other living cysts, some still in the thickened wall of the parent cyst, and others wholly apart from it in the peritoneum. So from some tumors dead changeless matters may be shed, and even from some cancers nothing else; but from cancers generally, and from some tumors having other names, there pass off elements which are equivalent to the cystic progeny of that ovarian cyst itself, not to its cast débris. Such elements, shed while alive, grow independently of that which produced them, and equally after its death or removal, and whether also they remain in their original place or be carried elsewhere with the movable fluids.

The tissues composing innocent tumors approach so nearly a perfection of growth as enables them, like the part they occupy, to endure, and some tumors having reached a certain size cease thenceforth to grow any more. But there is no such vital stability or such term of growth in the malignant tumors. Some indeed of their component substance, as the bony and fibrous case of medullary cancers, might live on, for their texture is true fibre and true bone. But the older elements of most cancers ulcerate, or wither, or die, and thus either remain unchanged among the more active parts, or slough out and leave cavities where once was a healthy organ. The cancer, living still, survives only in its youngest part.

The chief points of difference between tumors are set forth in the special descriptions which follow, but the *diagnosis* is facilitated by a methodical inquiry into the various particulars. Some of these can be noted at the first glance, and the eye often guides an experienced practitioner to facts which spare the patient a prolonged manual examination. Age and sex suggest many probabilities as to the nature of a tumor. Observance of region narrows the investigation to such tumors as can occur in structures known to exist therein. Study of form, magnitude, absolute or varying size, pulsation and bruit, vascular aspect, color, and relation to indigenous parts, now indicates and now excludes a tumor of a particular nature. Regard to the number of growths and the relation of those which are multiple to one another, further reduces the possible kinds of tumor which may be under examination. The history, both as to duration and as to foregone changes, sometimes clears up a difficulty, as when too brief existence distinguishes from cancer the pitted skin over a dense mass of suppuration. But the most trustworthy evidence is that obtained by the sense of touch, to educate and to rely on which is most important. Too often the statements of a patient are inconsistent with other apparent facts of his case, when the discrepancy may be decisively settled by an exact touch. By it an appearance of connection between tumours may be dissipated, as of chronic mammary with axillary hydatid. By it the broad distinction between solid and fluid tumors is usually easily made, the density of the one contrasting with the impressible or fluctuating character of the other. The wave of fluid in a tumor struck on one side and felt on the other loses distinctness as the tumor lessens in size, increases in tenseness, is divided by partitions, is deeply seated, or is closely bound with soft surrounding tissues. Thus hydatids and chronic abscesses become difficult to distinguish, or varicocele within an unusually dense fascia, uterine and ovarian tumors, or a deeply seated and tense mammary cyst, which acquires a deceptive granular exterior from the adhesion of the lobules around it. On the other hand, a tumor which is not a cyst may fluctuate from having a loose central texture infiltrated with liquid or with oil. Soft cancers may thus be almost more than elastic, and they are sometimes opened as abscesses; and large fatty tumors within the abdomen have proved indistinguishable from fluctuating cysts. But with all care in estimating the various indications of the nature of a tumor, it is sometimes impossible to ascertain those which would be decisive; and it may be advisable to puncture with a fine trocar a tumor suspected to contain fluid, or even to take a small portion from one that is solid for examination with the microscope. In most cases of doubt, however, the practical conclusion is often obvious enough without such preliminary investigation, that, whichever it be of alternative tumors, the growth may with equal propriety be removed.

TUMORS.

By Sir James Paget, F.R.S., and C. H. Moore, Esq.

Revised by Morris Longstreth, M.D.

The subjoined classification of the non-malignant tumors will be here followed:—

I. Cystic tumors; cysts.
- *A.* Simple or barren.
  - Serous; hygromata.
  - Synovial.
  - Mucous.
  - Sanguineous.
  - Oily.
  - Colloid.
  - Seminal.
- *B.* Compound or proliferous.
  - Complex cystic.
  - With intra-cystic growths.
  - Cutaneous.
  - Dentigerous.

II. Solid tumors and outgrowths.
- Fatty; adipose.
- Fibro-cellular; connective-tissue; glioma; myxoma.
- Fibrous; fibro-muscular; fibro-nucleated; fibro-plastic.
- Cartilaginous; fibro-cartilaginous; mixed.
- Myeloid.
- Osseous.
- Glandular.
- Vascular.
- Recurrent; Sarcoma.
- Neuralgic.
- Pulsating.
- Floating.
- Phantom.

[The classification given by the authors is not used by pathologists or surgeons at the present time, and therefore it will be useful to speak of the many methods which have been employed at different periods to arrange the various tumors or new formations. No system of classification of tumors has obtained the common consent of the profession for any great length of time, and in these later years, since such great advances have been made in the accuracy of the methods and means, both of clinical and of histological studies, but especially the latter, no system has been able to maintain itself very long. Nearly all the earlier methods of nomenclature were founded on what may be called the symptomatic or prognostic basis, having for subdivisions, classes named from some general characteristic (consistence, hardness, vascularity, etc.) or the chemical nature (serous, mucous), or, again, the anatomical structure (fibrous, glandular, osseous). This basis is the one followed by Paget, but recently, most surgeons and pathologists have abandoned the idea of allowing the symptoms or prognosis to have any part in the classification of tumors. Many years ago, an attempt was made to divide tumors, as well as all diseases, according to their nature and causes, but this attempt was a failure, from a deficient knowledge of the natural history of diseased processes.

Unquestionably, the true basis of classification of all tumors, as well as of all diseases, is that of their physiological pathology; to establish such a nomenclature would require a complete knowledge of their etiology, symptoms, prognosis, and anatomy, and in addition, would demand of us, at least, as complete information of the physiological working of morbid process as we possess of the normal. Alas! we do not possess this knowledge, and are compelled to accept a lower basis as our standard of classification. We yield to this necessity because a knowledge of anatomical structure only has been acquired. The same reasons which prevent a complete and perfect knowledge of normal physiology being attained, deprive us, in even greater degree, from obtaining a clear perception of the workings of diseased processes. But

in yielding, we would do well to remember the higher standard, and to constantly keep in mind that our object is to know the origin, mode of life, and of death of tumors, rather than simply their morphological details; to endeavor to remember that our aim must not be limited to the microscopical field of view, and to strive to grasp, not only the anatomical details, but the nature and cause of the pathological disturbances; we possess a fairly accurate knowledge of the histological appearances of new growths, but it is very necessary to increase our belief in the fact that they are governed by the same physiological laws as normal processes. This principle was, in all its essentials, very early recognized, but became lost to view through a deficient anatomical and physiological knowledge. John Hunter propounded the law that every new formation took its departure from an exudation of plastic lymph; it was not then known that cells were the essential element in this lymph, neither was it known that the fœtus was developed from a cell. The plastic lymph, and the new formation resulting from it, was regarded as something foreign to the organism, and was, therefore, a parasite. This belief was but a continuation of the very ancient religio-medical opinion that all diseases were a possession of the devil,—that, in other words, the devils entered into the body.

In spite of the good start, in what we now know to be the right direction, the law of Hunter became buried in a mass of theories; it was in opposition to all prevalent beliefs and prejudices of the time. And even after the discovery of the cell, and development of the cell doctrine (omnis cellula e cellulâ), the belief in the parasitic and foreign nature of new formations was still maintained, and spontaneous and extraneous origin was transferred from the tumor, as a whole, to the primitive cell of the new growth. This primitive cell was regarded as foreign, and its growth as separate from, and independent of, the laws regulating normal tissues. After the establishment of the cell theory, came the question of the origin of the cells and the development of the vascular system on which the new growth depended. For a long time it was contended that the cells arose in the plastic lymph, by the putting together of the minute granules always present in the exudation fluid. The origin of the minute granules was left undecided. When the essential part played by the cells in new formations was acknowledged, the bloodvessels became a secondary consideration, and as it was shown subsequently that the bloodvessels were always the offspring of pre-existing vessels in the normal tissue, a good part, if not the whole, of the distinct and independent nature of tumor-growths was taken away. Where then exists the cell, and whence does it come, from which the tumor takes its origin? Virchow, to whom, in great degree, belongs the honor of promulgating the views at present held on this subject, said that the cells at the point of departure of the tumor multiplied by division, and that the new growth substituted a certain amount of the normal tissue. Cohnheim showed that an emigration of white blood-corpuscles may also furnish the elements from which a growth takes place and increases by cell-division; in this case the parent cells do not exist at the seat of growth, but are found in the blood, in the spleen, in the lymphatic glands, or, as lately proposed, in the marrow of the long bones. Of course, the cells from which the tumor arises do not acquire the morbid propensity until after they have left the parent soil. Both the views of Virchow and those of Cohnheim are probably too contracted, and rather than adopt one to the exclusion of the other, Stricker has suggested that each finds its exemplification in the production of morbid growths; in some cases, emigration; in others, autochthonous cell-division, as according to Virchow; while in other cases both processes contribute to the formation of the neoplasm.

The present acknowledged system of classification is the anatomical, having for its underlying philosophical principle the genetic relations, which the tissue or growth bears to the primordial tissue of the fœtus. Whilst all writers are pretty much agreed as to the general basis of classification, the results, as seen in the groups given by each, are certainly not very satisfactory, and the differences of arrangement are inconsistent and in many cases most startling. It is difficult to find harmony or consistency where we see carcinoma classed by one author with fibroma and lipoma, and by others placed with epithelial growths. Or, again, to see myxoma placed by one along with carcinoma, by another among the connective tissues; again, a papilloma with an angioma, by others with a carcinoma.

That the system has great deficiencies is evident in the first place, because no two authors are agreed as to the number of groups necessary to include all kinds of growths; secondly, because there are great differences of opinion on merely histological questions, and thirdly—and this seems to be the greatest difficulty—the genetic relations of the various normal tissues on which this classification rests are not known, or at least not universally acknowledged. Surely, if the genetic relationships of the cells found in a carcinoma

of the liver were not well known, Cornil and Ranvier could not be justified in speaking of it as an alveolar fibroma, or of classing such a growth with syphilitic gumma, tubercle, and glanders. In settling the genetic basis for the classification of tissues it is necessary to determine the point in fœtal development at which we shall consider the differentiation of tissues sufficiently complete to base our nomenclature. Shall we select the stage when the three embryonic layers are developed, the inner, middle, and outer; or shall we defer the time till we find the various organs distinctly formed, and their intimate structures recognizable by the microscope; or wait until they have reached the complete fœtal development? If our classification is made on the anatomico-genetic basis it is demanded of us to select one of these three periods or stages, and by common consent one stage alone should be adhered to by all. If the attempt should be made, which has not been done, to choose the three layers of the embryo as the genetic types for classification, we are at once met with a difficulty as yet unsolved: it is impossible to point out a sufficient anatomical histological distinction between tissues composing the outer layer and those developed from the inner or mucous-membrane layer; both are in a certain sense epithelial, and each have connected with them secerning glands built on the same type. A partial attempt to use this basis in the classification of histioid growths has been made by Rindfleisch. This author divides all pathological new formations into those which are exclusively the effects of the intermediary nutritive apparatus; and secondly, those which are abnormal effects of epithelial growth.

This system of classification, having for its foundation three types of tissue, related respectively to the three—outer, middle, and inner—layers of the blastoderm, unfortunately cannot be carried out completely, as would be so desirable, because, as yet, we have only an uncertain knowledge of the evolutional history of the cell-elements composing the primary layers of the developing ovum. In the liver, for example, this want of knowledge is conspicuously displayed, although the assertion of facts in respect to its structure are numerous and positive; of the histogenesis or line of descent of the liver cells we may be pretty certain that they are derived from the inner blastodermic layer, but of the fibrous tissue of the organ the question may be considered an open one. While to all appearances from the nature of its structure and its relation to other connective tissues it would seem to belong to the middle blastodermic layer, yet found, as it is, placed among the gland cells, this intermingling may well lead to doubt of its histogenetic classification. How much more difficult becomes the classification of a new growth arising in the liver!

Virchow has selected, as the basis of his arrangement of tumors, the fully developed tissues, and his nomenclature, to which a large majority of writers adhere, conforms to the histological relations of the morbid to the normal growth.

The following schedules will show the varied opinions of some authors as to the proper classes to which new formations belong, and also the points of agreement and disagreement in respect to the nature of these growths.

CORNIL AND RANVIER.

1st. *Embryonal tissue.*
- Sarcoma.

2d. *Connective tissue.*
- Myxoma.
- Fibroma.
- Lipoma.
- Carcinoma.
- Tubercle.
- Syphilitic gumma.
- Glanders.

3d. Enchondroma.
4th. Osteoma.
5th. Myoma.
6th. Neuroma.
7th. Angioma.
8th. Lymphoma.
9th. *Epithelial tissue.*
- Epithelioma.
- Papilloma.
- Adenoma.
- Cysts.

10th. Mixed tumors.

GREEN.

I. Fully developed connective tissues.
1. Fibroma.
2. Lipoma.
3. Enchondroma.
4. Osteoma.
5. Myxoma.
6. Lymphoma.

II. Higher tissues.
1. Myoma.
2. Neuroma.
3. Angioma.
4. Papilloma.
5. Adenoma.

III. Embryonic tissue.
1. Sarcoma.

IV. Epithelial tissue.
1. Scirrhus.
2. Encephaloid.
3. Colloid.
4. Epithelioma, adenoid cancer.

V. Cystic Tumors.
- Cysts.

RINDFLEISCH.

A. Pathological new formations, which are exclusively the effects of the intermediary nutritive apparatus.
1. Interstitial inflammation.
2. Non-inflammatory hyperplasia of connective tissue.
3. Specific inflammations.
4. Histioid tumors.
   a. Sarcoma.
   b. Lipoma.
   c. Enchondroma.
   d. Myxoma.
   e. Osteoma.
   f. Myoma.
   g. Neuroma.
   h. Histioid mixed tumors.

B. Pathological new formations, which are abnormal effects of epithelial growth, with and without the participation of the vascular connective-tissue system.
1. Glandular carcinoma.
2. Epithelial carcinoma.

VIRCHOW (Modified).

I. 1. Fibroma.
2. Myxoma.
3. Glioma.
4. Lipoma.
5. Chondroma.
6. Osteoma.
7. Lymphoma, lymphadenoma.
8. Angioma.
9. Lymphangioma.
10. Sarcoma.

II. Myoma.
III. Neuroma.
IV. 1. Clavus.
2. Papilloma.
3. Glandular hypertrophies.
4. Adenoma.
5. Squamous epithelioma.
6. Cylindrical epithelioma.
7. Hard carcinoma.
8. Soft carcinoma.
9. Endothelioma.
10. Cylindroma.

V. Cysts.
VI. Mixed tumors.
VII. Granulation or infectious tumors.

LÜCKE (Billroth's and Pitha's Surgery).

I. Cysts.
II. Neoplasms.
A. New formations of the connective-tissue type.
1. Normal connective tissue.
   a. Fibroma.
   b. Lipoma.
   c. Chondroma.
   d. Osteoma.
2. Embryonal connective tissue.
   a. Myxoma.
   b. Sarcoma.
   c. Connective-tissue (cancer.)

B. New formations of the epithelial type.
   a. Papilloma.
   b. Epithelioma.
   c. Carcinoma.

C. Higher types of tissue.
   a. Angioma.
   b. Neuroma.
   c. Adenoma.

S. W. GROSS.

Benign tumors.
1. Cystic.
2. Hydatid.
3. Myxomatous.
4. Lipomatous.
5. Fibrous.
6. Cartilaginous.
7. Osseous.
8. Papillary.
9. Polypoid.
10. Myomatous.
11. Vascular.
12. Neuromatous.
13. Adenoid.
14. Lymphatic.

Sarcomatous tumors.
1. Round-celled sarcoma.
2. Spindle-celled sarcoma.
3. Giant-celled sarcoma.

Carcinomatous tumors.
1. Scirrhus.
2. Encephaloid.
3. Epithelioma.
4. Colloid.
5. Melanosis.

It will be of advantage now to speak of each class of tumors as given in the original text, and to add such matter to the author's description as more recent discoveries and growth of opinions require. The new classes will be interpolated, where the author's classification does not give such as are found in the above schedules.]

Cystic tumors consist essentially of abnormal cysts, sacs, or bags, filled with fluid or other substance produced by secretion or growth from their walls. Some appear to be formed by the increase and coalition of spaces in the connective or other tissues, in which spaces fluid accumulates, and becomes gradually encysted by the definition and more distinct organization of its boundaries. Such is (1), probably, the origin of many synovial or bursal cysts, and of some cysts in tumors. But (2) many more cystic tumors are formed by the morbid growth of natural ducts, or sacculi. Such are many mucous, sebaceous, and other cysts. (3) Some are protruded portions of a serous membrane, which separate from that membrane by closure of their canal of communication, in the way which is natural in the case of the tunica vaginalis testis. Thus, closed cysts,

symmetrically placed outside the femoral rings, appear to be detached portions of peritoneum. Others, which once communicated with the sub-arachnoid cavity through a bifid spine, are severed from it in later life by the union of the arches of the vertebræ. And (4) many are due to the enormous growth of elementary structures which increase from the form of cells or nuclei, and become sacculi with organized walls capable of secreting or producing other growths. After this brief indication of the general modes of origin, by one or other of which it is probable that all abnormal cysts are derived, the pathology and surgery of each kind may be more fully considered.

[The division of cysts given in the text is not the one now most generally made. These bodies, many of which are not regarded by some writers as tumors, in the strict acceptation of the term, have been classified in three different ways. First, according partly to their contents, and partly to the organ with which they are connected. Secondly, according to the mode of their formation. Thirdly, strictly according to the anatomical nature of their contents. It is a fact, however, that their structure, varieties, and mode of development are so diverse and involved that an entirely satisfactory and comprehensive classification is impossible. Some contend that a connective-tissue membrane or proper cyst-wall and an epithelial (or endothelial) lining are essential constituents of every cyst, and exclude all cavities not having such an envelope, as, for example, the cysts formed in the interior of divers tumors or organs, which are formed by degeneration of the tissues which surround them.

A very good general division of cysts is given by Billroth. He speaks of cysts developed from sacs already formed (true cysts), and of those altogether newly formed (cystomata). But even by this method of division it is difficult to arrange all cystic developments. Some apparently belong under both headings, as, for example, cystic disease of the thyroid gland.

The classification according to the mode of development is the best. Here we have :—

1. Retention cysts, which are formed by the retention of the secretion of a gland, which normally reaches the skin or mucous membrane. The usual condition preliminary to the production of this variety of cysts is something which occludes the ducts or mouths of secreting glands or tubes, and which converts them into closed cavities in which the products are retained and accumulated. The ducts may be closed by inspissation of the secretion, by foreign bodies intruding themselves, and by obliteration of the canals from external pressure or from inflammatory changes within or immediately surrounding them (skin and mucous glands, the gall-bladders, kidneys, and the salivary glands). Again, retention cysts result from the cohesion of the termini of the papillæ, or processes of dendritic vegetations (cystic papilloma and others). The contents of this variety of cysts vary very greatly ; some have solid cheese-like material, others oily, and others glairy mucus, depending in each instance on the gland or organ involved and the stage of the process.

2. Exudation cysts.—These cysts may also be called accumulation cysts, to distinguish them from the previous class, in which the contents are derived from a special secreting apparatus. Like the previous class the sac already exists, but unlike them the cavity is from the first a closed cavity, and not one formed by the closure of a normal outlet or duct. The accumulation and distension are produced by an exudation, generally of a kind normal to the part, but which contains an excess of the normal salts, albuminous, or fibrinous material in varying proportions. Of this class bursæ mucosæ, serous sacs, cerebro-spinal cavities, etc., furnish the larger number of instances. The watery character of the contents is expressed by the various names which they bear, as hygroma, hydrops, etc.

3. Extravasation cysts.—Here we are concerned mostly with a hemorrhage in the parenchyma of an organ or into the interstitial connective tissue. We scarcely would speak of a recent bleeding or blood-clot as an extravasation cyst ; it does not receive this name until after the cyst-wall is formed by the condensation, etc., of the surrounding tissue. Occasionally a cyst is immediately formed, for example, when blood is effused between the layers of a fibrous membrane and remains fluid. The contents vary from fluid blood to a clear serous fluid in which blood-crystals alone remain to attest its origin. In their late stages, and even in their origin, these cysts may be undistinguishable from the preceding class.

4. Softening cysts.—In this class, and to a certain extent in the preceding one, we have to do with cysts of new formation. To this class has been applied the name cystoma, to indicate their relationship to the general class of tumors or neoplasms, and to show that they are produced by such definite morbid processes as lead to the growth of new formations. The pathological process here concerned leads to the formation of a fluid, it may be in normal tissues, or it may be in preformed new growths. During the process of formation these cysts are deficient

in a cyst-wall, and for this reason they have been by some denied admittance into this class of growths. It is not until they have ceased to extend peripherally that an enveloping membrane partitions them off from the surrounding tissue, and in this, so to speak, completed condition they bear a close resemblance to exudation cysts, and may then receive accretions to their contents by the same process as this latter class.

In this classification of cysts no mention has been made of barren and proliferous, or of unilocular and multilocular, or again, of exogenous and endogenous—words so frequently in use formerly—and they have been excluded with a purpose. The names barren and proliferous signify conditions and not modes of formation of cysts, and they arose from ignorance either of the pathological processes or of the histological structure. The barren cyst is one either in which the process of production has ceased, or in which a structureless wall exists, or whose existence or nature was ignored, as, for example, the simple serous cysts (exudation cysts). The proliferous cyst is one in which the process is in activity, or which shows a cellular lining in an active budding condition. Now in truth such a barren cyst—barren in its fully developed condition—as a sebaceous follicle or cyst was at one time in a most active stage of proliferation, and its whole contents are due to the proliferative action of its former lining of gland-cell epithelia, now destroyed by pressure. Many barren cysts of this variety again take on active proliferation, if a portion of their contents is removed and the cell lining thus relieved from the pressure of distension.

The names unilocular and multilocular, as descriptive of different varieties of cyst growths, have to a great degree lost their value, and have only been retained for their usefulness in description. We know that a unilocular cyst which, during its growth, becomes lined with a dendritic vegetation of papillary out-growths, may by the process of cohesion of their termini become multilocular (retention cyst of papilloma cysticum). A multilocular cystoma may, by the process of distension and the breaking down of its septa, become unilocular.

Serous cysts, simple and barren, are probably the most numerous of the whole class. The name may include such as have been named hygroma, meliceris, and many forms of hydrocele; and, generally, all the cystic tumors which have thinly liquid or honeylike contents of yellow, brownish, or other tint, not very different in consistence from serum of blood. They may occur in almost any part of the body. By far their most frequent seats are in or near glands or gland-like structures, as the kidneys, the thyroid, the mammary gland,[1] the labial, and others; but they are not rare in the subcutaneous tissue, especially of the neck and trunk; they may be found too in nerves, in bone, in muscle, etc. In the neck they have been often described as "hydroceles of the neck."

The most frequent serous cysts have their membranous walls white and moderately vascular, formed of connective tissue, usually too firmly connected with the surrounding parts to be easily detached during life, and generally lined with a tesselated epithelium, or a nucleated membrane. Such serous cysts may be single, or multiple and clustered; hundreds, even, may be collected in one part or place, and may either communicate freely, or be merely collected in one mass of tissue. Their contents may be, and most of them are, like ordinary serum; but they may be thick and honeylike; or may have various tints of green, olive, brown, ruddy, or red; or they may glisten with crystals of cholesterine; or may have fibrine, and coagulate on removal; and as yet no relation or correspondence can be traced between the cyst-walls and their contents; there is no such variety in the former as in the latter.

No general rule can be stated concerning the origin, manner, or rate of development and growth of serous cysts. Of those that are of chief importance in surgical practice, some seem to originate in transformations of the structures of nævi, and are traced to the time of birth or earliest childhood; some, as the ovarian, beginning in enlargement of Graafian vesicles, are diseases of puberty or later life; some, again, as the mammary, are most apt to originate during or after the time of natural degeneracy of the milk-glands. To many others no date at all can be assigned. With the exception of the ovarian, those grow largest which begin in youth, and spread in loose tissues, as in the axilla. The increase of most others is moderate, and they may long remain stationary.

For the diagnosis of serous cysts seated in external parts these are the chief facts to be remembered. They are usually regular, well-defined swellings; smooth, round, oval, or, more rarely, lobed; movable with, not in, the surrounding and generally healthy or only wasted parts; painless; covered with healthy integument. In some situations they are trans-

[1] The special characters of the cysts in each organ will be described in the parts devoted to the surgery of the thyroid, mammary, and other glands, etc.

lucent. Where they are large and not very tensely filled, they may give the sensation of perfect to-and-fro fluctuation; but in many instances, especially in the mammary gland and by the gums, they are so tensely filled, that the detection of fluid must rather be by their admitting of deep central pressure, and instantly recoiling as the pressure is withdrawn. By one or other test of fluid, its presence can be generally ascertained. The diagnosis is made more probable if the tumor that has these characters be in the neck, the mammary gland, or the gums; if in the first situation, it had its origin in some congenital error; or if in the second, it was first noticed during or near middle age, or can be partially emptied through the nipple.

The diseases most likely to be confounded with serous cysts are the softer kinds of solid tumors, as the glandular, fibrocellular, soft cartilaginous, etc.; abscesses, especially the chronic; and cystic tumors of other kinds. For help in the diagnosis from solid tumors, the characters related above may be compared with those that will be assigned presently to each kind of tumor; but chiefly the detection of fluctuation, or of the yielding and immediate recoil of fluid, must be relied on. Serous cysts assume the characters of a solid tumor, when deeply seated and tensely filled and rendered uneven by the close adhesion of rough surrounding textures. From acute abscess, the diagnosis is usually made clear by the pain, and other signs of active inflammation; from chronic, with more difficulty, by the walls of the abscess being usually thicker, harder, and less pliant, so that the borders feel much denser than the central part. From other barren cysts, the diagnosis may depend wholly on the localities in which they are severally found; but this will be generally sufficient.

The treatment of serous cysts must greatly vary in different cases. Referring here to none but those in external parts, some are too large and involve too many and important parts for curative treatment, but any may be punctured, whether for help to diagnosis or for beginning treatment; puncture alone, however, is very rarely curative, though it may be successful when followed by a chilling lotion or by pressure. Some may be cured by external irritation; those in the mammary gland are commonly thus curable, either before or after tapping; with others the same remedy more often fails. Iodine injections are often successful, especially for serous cysts in or near the thyroid gland. Setons may succeed where these have failed, but they are apt to inflame the cyst too much, and with very large cysts may be dangerous. The cysts by the gums are best treated by being widely laid open, and either cauterized within or filled with lint, so that they may freely suppurate. Those in bones may be treated in the same way; and similar means may be used, if milder measures fail, for any that are not too perilous by size or depth. Complete excision is rarely necessary for simple serous cysts, for such portions as may be left will granulate and scar. But if the cysts be multiple and clustered, it is not sufficient to remove some of them: those which are left entire will continue to increase. Hence the occasional necessity of removing a whole mammary gland containing many cysts. The not rare connection of clustered serous cysts with venous nævi explains the serious bleeding which sometimes occurs during their excision, and which had better be anticipated in operations on those in the neck or near any large veins.

The prognosis of serous cysts is generally favorable. Once closed or cut away, no further mischief is likely to ensue. Yet in some cases great caution is necessary: for, in the breast, a coincidence, apparently accidental, of cystic disease with cancer is not very rare; in the neighborhood of a large cyst a small one may be overlooked, and may increase after a seeming cure; and it has happened that a serous cyst, after being obliterated by treatment, has been found to be part of a medullary cancer which its size had concealed.

Synovial cysts. (DISEASES OF BURSÆ.)

Mucous cysts [retention cysts], including all that contain a fluid like mucus, are commonly derived either from cystic disease of so-called mucous glands, or from dilatation of obstructed ducts or reservoirs. The chief of them are the Nabothian and Cowperian cysts, ranula, and cysts of the antrum, and of these it may suffice to say that their distinctive characters are like those of serous cysts, from which they differ only in the localities in which they are found. Where the one kind are rare, the other are common. As a rule, the sufficient treatment of mucous cysts is to lay them wide open, and then keep them open, or make them granulate: smaller measures are very rarely useful; but particular methods must be adapted to each form or locality. The prognosis is very favorable, for mucous cysts do not appear in the complications with which the serous are sometimes found. They are, however, more difficult to obliterate, and even long after apparent cure may fill again.

Sanguineous cysts [extravasation cysts. There are two distinct varieties, one of entirely new formation, the other from a

normal cavity], (hæmatoceles of the neck, and of any parts other than the tunica vaginalis) are very nearly related to the serous; differing only in their contents, in their occasional origin from violence, and in that they are usually single, never very numerous in a cluster. They are most frequent in the subcutaneous tissue in or near the neck or trunk, but not rarely they rise from the deeper part of a limb, and reach a large size. In such a position they are likely, even more than serous cysts, to be or to become the seat of medullary cancer, although, even when of large size, they may present on being opened and explored no trace of a solid growth. Their walls may be merely membranous, like those of the most frequent serous cysts; but sometimes they are remarkably fasciculate within, not very unlike the interior of an auricle; and sometimes they have minute cysts in their own substance. Those which are fasciculate appear to be formed by unequal distension of the natural tissues. The distending force may be a rapidly secreted fluid, but it is sometimes due to the rupture of a bloodvessel. In this way a cyst was formed in the popliteal nerve which filled the ham, although it originated in a rupture of the small artery and vein within the nerve.[1] The blood in some sanguineous cysts is clotted and partially decolorized, or mixed liquid and clot; in others it is liquid like ordinary venous blood, but coagulates when withdrawn. In the former case, it is probable that the blood is derived from an accidental hemorrhage into a serous cyst (as a hydrocele may be changed into a hæmatocele of the tunica vaginalis); in the latter case it is probable that the cyst has always contained blood, and has owed its origin to some transformation of the structures of a nævus, such as an enlargement and coalition of its venous canals or spaces. And this view is confirmed by the occasional existence of growths in which blood-cysts and nævus are combined; and of others in which veins are found opening into the cysts.

The diagnosis of sanguineous cysts from solid tumors, and all diseases other than cysts, must rest on evidences similar to those already stated for distinguishing the serous cysts. From these a diagnosis without exploration may be impossible. Both alike may be congenital, or may first appear at any later period; both may be connected with nævi; neither observes any definite rule of increase; neither belongs especially to any one period or condition of life, though both alike commonly come under treatment before middle age. A sanguineous cyst communicating with a bloodvessel may in some positions be made to vary in size.

The treatment of sanguineous cysts may resemble that of serous. Emptying by tapping is rarely successful, but may always be allowed the chance. Iodine or other stimulant injections may be tried; and, these failing, the cysts must be laid open or removed, with due care for the free bleeding that may ensue in those that are connected with nævi. The growth of cancer does not appear to be accelerated by opening and obliterating the foregoing cyst.

Oily and colloid cysts have too little practical importance to need more of statement than that the former may be found in the place either of cutaneous cysts or of dilated milk tubes, and the latter in any place where a serous cyst may occur, but chiefly in the thyroid gland and kidney. These, may, therefore, be passed by; and *seminal cysts* will be described among diseases of the testicle and spermatic cord.

Compound or proliferous cysts.—Under either of these names (but the second is the better) may be included all the cysts on whose walls vascular or other fully organized structures are formed. The boundary line between the barren and the proliferous is not well marked, yet the distinction has some practical utility.

When many simple cysts are clustered together, they may appear like a proliferous cyst; but in general the distinction can be ascertained that, in the one case, the numerous cysts are only contiguous, and in mutual contact at their adjacent walls; in the other case, some are inclosed within others, or are outgrowths from others' walls.

Among the varieties of proliferous cysts, distinguished, as they may best be, by their growths or other products, the chief are enumerated at p.238. The *complex cystic*, or *cystigerous*, growths are best typified by examples of the complex ovarian cysts, and by the cystic disease of the chorion, the so-called hydatid mole. The importance of the former in practice is almost entirely confined to those that occur in the ovaries. In other parts they are extremely rare; there are no sufficient signs by which to distinguish them from the multiple or clustered simple cysts, and their treatment must be the same.

[In respect to the general class of proliferous cysts, we have already stated the modern views of the inutility of this division. The impossibility of this distinction is especially true as concerns the *complex cystic* or *cystigerous* growths, especially those of ovarian origin. The ovarian cysts arise in general either from a colloid de-

[1] Med.-Chir. Transactions, vol. xlix., p. 29.

generation of the Graafian follicles or from a similar change affecting the connective-tissue stroma of the ovary. The cysts with intracystic growths, in the study of which Paget has mostly relied on tumors of the breast, are now generally classified by authors, not under cystic growths, but under the head of tumors which in many instances become cystic. In fact it would seem that Paget has described the proliferous cyst as the origin of the tumor, and the intracystic growths as something produced, by an irritative process, from the cyst wall—in other words, he has mistaken the accident for the chief factor in the morbid change, because, as is now well known, the cystic cavities of these tumors are due to changes of the new formations either in the pericanalicular or endocanalicular tissue which is represented, and the fluid filling the cavities is either of the nature of a retained secretion or an excretion from its cellular lining. That the cystic cavities are the accidental quality of these tumors is evident from the fact that in the early stages the cysts are inconspicuous and the tumor is solid; the older they become the larger are the cystic cavities and less active are the proliferative qualities of the cellular lining, since the cells become destroyed or atrophied from the pressure of the contained fluid. It is evident, as M. Labbé remarks (Labbé et Coyne, Traité des tumeurs bénignes du sein, Paris, 1876, pp. 50–54) that Paget has examined these growths only in their completed stage, and has not studied the process of development. Therefore, most of these cysts are left for description and study under the heads of the various classes of tumors in connection with which they occur, viz., the cystic sarcomata and cystic adenomata, as well as other varieties, and to which special reference will be made in connection with the organs in which they occur with special frequency.]

Cysts proliferous with vascular growths, including most of the "sero-cystic sarcomata," are most frequently found in or near glands, especially the mammary, labial, thyroid, and prostate glands; but they may be found also in the subcutaneous tissue, and in deep intermuscular spaces.

The walls of these cysts, which may be either single or multiple, are usually formed of thin connective tissue, smoothly lined within, and externally combined closely with the surrounding structures, so that they are not easily dissected out entire. Their cavities, till they are filled with the vascular growths, may contain either serum or any of the fluids that occur in the simple cysts of the same parts. The intracystic growths, according to their duration, or the proportion between the rate of their increase and that of the cyst, fill more or less of the cavity. They appear to spring from single points or spaces on the inner wall of the cyst; thence enlarging and extending, they may gradually fill it, excluding the fluid which at first surrounded them, and then, it may be, uniting with those parts of the inner surface of the cysts from which they did not spring, and coalescing with them so as to form a solid tumor, around which the former cyst-walls appear as a capsule. By still further increase the intracystic growths may protrude through the cyst-walls and their superjacent tissues, and thence may project as "fungous growths," looking like cancerous excrescences.

The form of the intracystic growths is, in different instances, extremely various. Some are low, broad-based, like heaps of granulations; some are very lobed and "cauliflower-like;" some are variously branched with narrow leaf-like processes, clustered and arborescent. Their structures are not less various. Some are soft, yellowish, like laminated fibrine-clot; some spongy and succulent; some are like soft gelatine; some firm, like mammary gland. Again, they are all variable in vascularity, and therefore in their tints of color; cysts may form in them; they may be diseased or degenerate.

The minute structure of the intracystic growths connected with glands is generally glandular, imitating the structures of the corresponding glandular tumors, but more often than in them very rudimental, or imperfect, or altered by degeneracy or disease. (See Fig. 36.) In other parts they appear, generally, like the structures of granulations, and other examples of developing connective tissue.

In the diagnosis of this form of proliferous cysts (sero-cystic sarcoma, cysto-sarcoma), one looks first to their seat. They are not rare in or near glands, or structures beset with glands; they are very rare in any other situations. Their shape is generally roundish or oval, sometimes lowly lobed or tuberous; they are well-defined and movable. If they still contain much fluid, this may be detected by the tension and elasticity of the cysts or by fluctuation. Before the skin gives way, and the fluid escapes, a characteristic bluish or black hue may come over the prominent soft lobes. Sometimes the combination of solid and fluid may be detected, as when one feels a hydrocele with the testicle behind the fluid. If there be little or no fluid, the tumor may not be distinguishable from a soft glandular or fibro-cellular growth. There may, indeed, be no distinction possible, seeing that many of the solid tumors thus named very probably originate in such intracystic growths as are here described. The size of the growths will rarely help a

diagnosis; they may be of any size, from one just discoverable to a foot in diameter. The structures adjacent to them are always healthy, unless when they have protruded; and then the integuments or other structures, through ulcerations of which they have passed, are thinned out to the apertures of ulceration, but are otherwise not diseased. The surface of the protrusion is usually like that of ordinary granulations; florid, soft, elastic, pliant; bleeding easily on contact, yet not profusely. Sometimes the foliated arrangement of the growth is distinguishable as it lies in or projects through the circular aperture of healthy skin. The protrusion of the growth may cause general disturbance or some cachexia; but, except in this case, these tumors are not attended with ill health; and their ordinary history before they come under treatment is, that they have been long observed increasing slowly and without pain, though it may be with occasional more rapid enlargements. The age at which they appear is not distinctive, for, while they are most common in the breast between thirty and forty years of age, they are met with up to seventy-five.

By all these characters the most important diagnosis of the proliferous cysts —that, namely, from cancer—may usually be made. It may be nearly impossible to distinguish them, on the one hand, from simple or clustered cysts; and, on the other, from glandular or fibro-cellular solid tumors: but this diagnosis is of comparatively little importance. From cancers, especially the medullary, which they most resemble, they must be distinguished by the signs just enumerated; to which may be added the absence of corresponding disease in the lymph-glands and other distant parts.

Excision appears to be the best remedy for all these proliferous cysts. In the breast, the close adhesion of the cyst to the adjacent structures may require that they should be removed with it; in other parts, the cyst may usually be removed alone.

The prognosis, after removal, is favorable. But by no means rarely cases occur of repeated recurrence of proliferous cysts in the breast; and this event may be feared when care is not taken to remove the whole, and when the intracystic growth, and in less degree the cyst-walls, are particularly soft, succulent, and of gelatinous appearance. The account of cases of such recurrence will be given in the section on recurrent tumors.

Cutaneous cysts.—Under this name may be included all those whose walls have the structure, or form any of the usual products, of skin. Some of them, especially those which are congenital and those which grow in the ovaries, have evident cutaneous structures lining them; cutis, epidermis, hair-follicles, etc.; in others, including most of those that have been called sebaceous, epidermal, and atheromatous cysts, there are only such materials as the skin, or some of its included organs, produces.

The cutaneous cysts in ovaries need be mentioned here only as being types of the whole group in respect of the completeness of the cutaneous structure, and the abundance of perfect hair, epidermis, and other structures that they produce. And those that occur in other parts than the subcutaneous tissue have their sole or chief interest in their singularity and rarity. They have been found in the testicle, lung, kidney, bladder, sublingual tissue, and within the skull; in the last situation being probably such as were formed in fœtal life, and shut in by the gradual closure of the ossifying skull. But of all these, no diagnosis or general rules of treatment can be given. Of those that are found in the subcutaneous, or just deeper, structures, it is useful to distinguish the congenital from those that form first in later life.

[Under the head of cutaneous cysts the author has included varieties of growths which, under the present method of classification, are now widely separated, and which are, also, evidently widely separated in their mode of origin. The *first* class mentioned in the text are now spoken of as dermoid cysts or tumors, and where their contents are greatly diversified by the presence of one or more highly organized tissues of the body (teeth, bones), Virchow has named them teratoma. The *second* class are simply retention cysts, due to the closure of the excretory ducts of the follicles. The dermoid tumors are invariably of congenital origin, and their walls repeat the textural and structural relations of the outer skin, which, with its appendages, forms a closed sac with the epithelial surface turned inwards. The epidermis shows the typical separation into a horny and mucous layer; the hair follicles are scarcely to be recognized, neither are the sebaceous glands. Papillæ certainly are not present with the same regularity as in the outer skin. These cysts are very distinctly separated from the surrounding connective tissue. Teeth, which occur with great frequency in them, are complete in all their parts, and are sometimes found embedded in bony sockets. The bones which occur also are covered with periosteum, and are supplied with vessels, and exhibit normal articulations. More rarely, nervous and muscular tissues are present.]

The congenital cutaneous cysts are by far

most frequent under the eyebrow or in some other position in or near the orbit. They may occur in any other part, but no general account could be given of any but those in or near the orbit. Here they are usually round or oval; often flattened; deep-seated, resting on or embedded in the frontal bone; and in some cases even prolonged through apertures in the inner wall of the orbit into the ethmoidal cells or the cranial cavity. Their walls are very thin, membranous, white, formed of perfect connective tissue, very closely connected with the textures around them, lined within with perfect epidermis, and often showing hairs like fine eyelashes, growing from perfect follicles. Usually they are filled, but not tensely, with turbid or oily liquid; or with sebaceous or spermaceti-like substance, including cast-off hairs.

Cysts of this kind are usually of slow growth. They increase in the first years of life at a scarcely greater rate than the rest of the body does, and they rarely attain a greater diameter than about two-thirds of an inch; they are usually less. They may, however, enlarge by unusual increase of their contents, and inflaming at last may ulcerate.

By the characters just described, the diagnosis of these congenital cysts is not difficult. The existence of one may be believed in any case of a small growth having the general characters of a cyst, seated near or just within the upper or the inner boundary of the orbit, observed at birth or in early childhood. A nævus may present some of these characters, so may a fatty tumor or a serous cyst: but the diagnosis of the latter is not very important; and that of the former may rest on its greater softness, compressibility, and pliancy; the bluish tint, or visible bloodvessels, over or near it; its soft puffy feel, its pulsation, or its variable size.

The only appropriate treatment of these cysts is excision. The depth of the cyst and its close adhesion to all the parts around it, and especially to the periosteum and bone, make the operation and the subsequent healing almost always very tedious. Care should be taken to dissect away the cyst entire: for if its contents escape during the operation, the remainder of the dissection is made much more difficult; and if a portion of it be left, it may continue to produce cuticle and sebaceous matter, and prevent the healing of the wound. Generally, the immediate union of the wound should not be attempted, lest pus form and burrow under the orbicularis muscle. If the removal of the cyst be complete, no return of the disease is to be feared.

The more common cutaneous cysts, which are not congenital or formed in earliest life, have rarely so complete and perfect structures as those just described; only their contents are always like the epidermal or other products of skin, more or less perfect or degenerate. In different specimens the walls of these cysts are widely various. In a great majority they are thin, pliant, formed of healthy-looking connective tissue, loosely connected with the surrounding textures, and lined with smooth shining cuticle. In some they are thick, hard, laminated; in some, toughly fibrous; in some, calcified; but all these conditions are probably due to morbid changes in cyst-walls that were originally thin. In some rare instances the cyst-walls appear complicated by the growth of other cysts in or from their walls. Their contents are yet more various, and the varieties have suggested the several synonyms of cuticular, sebaceous, atheromatous, etc. Most commonly they consist of layers of white soft epidermis, easily scaling asunder, disorderly, and mixed with softer or liquid matter at the centre. In some instances, abundant crystals of cholesterine, mingled with the epidermal scales, give a peculiar glistening mother-of-pearl character to the laminæ of the cyst-contents; and many of these have been named cholesteatoma. And in many cases, probably through disease, or through degeneracy of the cyst-walls, the contents consist of turbid brownish, yellowish, or other colored fluids in which clusters of epidermal cells, with granular, earthy, and fatty matter and crystals, are floating. But however strange the contents may seem, the microscope will always disclose in them true epidermal structures; nucleated scales, filmy and folded, lying in clusters, or free, or collected in the form of laminated capsules (like those which some have thought characteristic of epithelial cancer). Often, too, the smell of cutaneous secretion is as evident as the sight.

The cutaneous cysts may be found under the skin of any part; but they are probably a hundred times more common in the scalp than in any other situation. Some of them have, in the skin over their chief prominence, a small dark point, through which a fine probe may be passed into their cavity; over others no such mark can be seen. And this difference indicates a difference in their modes of origin; namely, that the former are due to distension and overgrowth of hair follicles, whose orifices remain obstructed by the material of the dark point; and the latter are complete cysts, formed, it may be, after the fashion of hair-follicles, but having never contained hairs or possessed external openings. [These cysts originate

from the sebaceous glands, and are retention cysts by closure of the ducts. So far as is known, they generally start in glands connected with hair-follicles which are immature.] In either method the cysts are usually first formed in youth or early adult age, though they rarely come under treatment till many years later. They are very rarely referred to any local cause, but are commonly hereditary, though not connected with any constitutional peculiarity. Their rate of growth is uncertain. Many, after attaining a diameter of about half an inch, remain long or always stationary; others, even in the same person (for these cysts are often very numerous in the scalp), maintain a regular rate of increase, and thus some have reached a diameter of six inches. But when they grow very rapidly, or when they are actively inflamed, as after injury, it is common to find cutaneous cysts very thinly covered with ruddy or dry skin; and this, ulcerating, may permit them or their contents to protrude. Hence are derived most of the so-called "horns" of the scalp and face, and more rarely of other parts. Sometimes, too, it has happened that the protruded contents of an inflamed and ulcerated cyst have become vascular, grown rapidly, and formed a granulated bleeding mass, very like an exuberant epithelial cancer.

The sebaceous cysts which grow in the tympanum and external auditory meatus claim particular notice, as they sometimes prove fatal. They increase toward the bone rather than toward the cavity of the meatus, and having perforated by gradually producing absorption of the bone, they set up inflammation of the cerebral membranes and abscess of the brain itself. The importance of early treatment of these apparently trifling tumors is obvious. See DISEASES OF THE EAR.

[These cysts have been called cholesteatoma, and are, in the great majority of cases, nothing more than a retention of inflammatory products, the result of a purulent catarrh of the middle ear, accompanied with polypoid granulations and perforation of the membrana tympani. They are therefore retention cysts. In other cases they represent a true new growth arising from the bone or from some of the soft parts of the ear, and in these instances the clinical peculiarity exists that all inflammatory irritation in the neighborhood is wanting in the earliest stages of development, and the suppurative destruction is only shown later. The whole temporal bone may be infiltrated and destroyed, and by pressure on the neighboring tissues, from increase of the collection or the swelling of its mass by moisture and secretions, serious diseases, and even death may result (purulent sinus—thrombosis with pyæmia, meningitis, abscess of the brain).[1]]

In the scalp the diagnosis of cutaneous cysts is rarely difficult. The most important resemblance which they may bear is that to medullary cancers perforating the skull; and the distinction may be the more difficult as the skull is sometimes defective beneath a congenital cyst of the scalp. In other parts it may be difficult to distinguish them from chronic abscess, fatty or fibro-cellular tumor, acephalocyst, or any softish tumor. The chief points to be looked to, in addition to those that are common to all cysts, are their immediately subcutaneous situation; their regular, smooth, round or oval form, which may in some instances be made to change by pressure, when the contents are a soft substance that may be moulded into various shapes; the easy mobility; the dark central point; the hereditary origin; the slow growth; the healthiness of the immediately surrounding parts; the absence of change in them from the pulse or respiration, and of head symptoms when they are pressed.

The cutaneous cysts admit of several modes of treatment. Those that have the minute openings may be gradually emptied by dilating their openings and pressing out their contents; and being thus treated, they may be kept from being unsightly or otherwise troublesome, or may shrivel up and disappear. But if this treatment fail, or if there be no opening, and if either the size or any of the inconveniences of the cyst make their removal desirable, they may be extirpated with caustic or the knife. The latter alone might be advised, if it were not for the peril of erysipelas and other mischiefs that attend even minor cutting operations in some persons. Few surgeons of large experience have failed to see one or more deaths after the excision of cutaneous cysts, especially of those in the scalp. The treatment of wounds after operations by the sulphurous or carbolic acids, or by the chloride of zinc, is likely to reduce this mortality; but whenever there appears more than average risk of such a calamity, the caustic treatment should be employed. A space of half an inch or less in diameter over the most prominent part of the cyst being thoroughly cauterized with nitric acid or potash, the separation of the slough will lay open the cyst, which may then be left to empty itself and wither; or may be drawn out through the opening; or may be emptied with pressure and cauterized within. Or, in another

[1] Schwartze's Pathological Anatomy of the Ear.

method, the cyst being first punctured, its interior may be cauterized, and it will slough out.

When excision is to be practised, it is not necessary or usually advisable to dissect round the cysts. Their connections with the tissues next to them are generally so loose that, if they be freely cut into, they may be seized at their cut edges and pulled out. If the cyst have been inflamed, or become adherent by the changes induced by friction—changes which are chiefly frequent with those on the trunk and limbs—it may be necessary to dissect out the whole cyst, and perhaps to remove a portion of skin with it. In such dissections the possible connection of the cyst with the dura mater must in doubtful cases be remembered.

Cysts containing teeth are of two kinds. Some, found in the ovaries, or, much more rarely, as congenital growths, in other parts, contain, with one or more teeth, the products of skin, as hair, epidermis, etc. Others, occurring in the jaws, appear to be enlarged tooth-capsules, in which the teeth, through defective or erroneous development, have not been extruded. The former will be best considered among the diseases of the ovaries; the latter among the DISEASES CONNECTED WITH THE TEETH.

Fatty or adipose tumors and outgrowths (see Fig. 33) are the most frequent of all innocent tumors. They are commonly described under the names *lipoma* and *steatoma*, and afford good examples of the two modes of growth of tumors, the continuous, and the encapsuled or discontinuous.

The continuous or fatty outgrowths commonly appear as lumps of fat in the subcutaneous tissue, ill-defined, as if the ordinary fat of some one part had increased beyond all natural proportion to that of the parts around. The excessive double chin that some persons have is a growth of this kind; and others, more evidently morbid, and more rare, occur especially at the nape, or behind the ears, or over the lowest cervical vertebræ. [Diffuse lipomata rarely involve a whole limb or a portion of a member, and grow in between the muscles, tendons, vessels, and other structures.] They do not differ in structure from the ordinary fat of the adjacent parts, unless in being rather firmer; they are generally troublesome only by their ugliness; yet some patients complain of pain in and about them.

No good cause can be assigned for these hump-like outgrowths of fat. A child presented one in the lower part of the back of the neck, whose father had one in the corresponding place; and a woman, having seventeen of them, was aware of the existence of many similar fatty tumors in her father and grandfather. Generally they begin their growth in persons about forty years old, and slowly increase, till, attaining some uncertain size, they stay thereat. They appear not more liable to degeneration or disease than is the natural fat adjacent to them.

There is very rarely any difficulty in the diagnosis of these fatty outgrowths. They are evidently only too much subcutaneous fat in a certain place. And generally they are hardly amenable to treatment. Sometimes they may be cured by the long-continued taking of liquor potassæ; but if this fail, excision would remove them; and this is rarely advisable, for the scar of the operation would be as ill-looking as the growth.

Fatty tumors, properly so called, are far more common than these outgrowths. Their most frequent seats are the trunk, especially about its upper half, and the parts of the limbs nearest to it. The further from the trunk, the more rarely they appear; they are exceedingly rare in parts that do not naturally contain any adipose tissue; but, with the rarity of curiosities, they may be met with beneath the tongue, or in the peritoneum, or perhaps anywhere [even on the pleural surfaces, and the synovial folds of the joints. A unique instance of a fatty tumor growing between the hemispheres of the brain and moulded to the corpus callosum is recorded]. They usually lie in the subcutaneous fat, upraising the skin, and connected rather more closely with it than with any other of the tissues next to them.

Among fatty tumors, some are much firmer than others, and than the normal adipose tissue; and the firmer are usually smooth, round, or oval, or very largely lobed. These have generally tough investing capsules, from which partitions, extending inwards, intersect them, and make a kind of close brawny mesh-work filled with fat-cells. The firmer fatty tumors are, probably, more often deep-seated than subcutaneous; especially they are apt to grow near joints; but they are altogether much more rare than those of the softer kind. These, which are the common fatty tumors, resemble in their minute structure, with scarcely a difference, the natural adipose tissue.

[The lipomata belong to the connective tissue class of new growths. They are characterized histologically, in their origin and throughout their development, by a peculiarly central mode of growth, as distinguished from peripheral. First appears a circumscribed proliferation of connective tissue, and then the newly-formed connective-tissue cells become infiltrated with fat. This new-formed connective tissue forms the bond of union

between the new growth and the organism, and through this nidus the tumor receives its vascular supply. It is this point of origin which must be extirpated during operation to prevent the return of the growth. The lipoma imitates closely the panniculus adiposus of the body, but distinguishes itself by the large size of the individual lobules and nodules, as well as of the individual fat-cells, which are more fluid and richer in oleine, and therefore more elastic.

The lipomata are subject to various metamorphoses. A chronic inflammatory hyperplasia, affecting the connective-tissue trabeculæ, causes a partitioning of the growth into very distinct lobules separated by broad bridges of fibrous tissue (fibrous lipomata). This process is occasionally followed by a retrograde change with the formation of delicate calcified mesh-work, which still further increases its firmness and weight. Further, a metamorphosis or degeneration of the adipose cells into mucous tissue, and the transformation of the tumor into a myxoma may result. Billroth says the combinations of lipoma with soft fibroma, with myxomatous sarcoma, and with lymphoma may and do occur, though very rarely, and the same author has observed considerable cavernous dilatation of the veins in lipomata. Metastases to the neighboring lymphatic or to the internal organs are never observed. Recently there has been indicated the possibility of death from these usually innocent tumors, through fatty embolism of the lungs or the brain, but such a result must ever remain most problematical, since the resorptive apparatus of these growths is so poorly represented.]

They are generally of a somewhat round or oval shape, flattened if they lie with little prominence between the skin and fascia; pyriform if they are pendulous. Commonly they are deeply lobed, and large outlying lobes sometimes extend from them, and dip far into the adjacent fat, or, rarely, through the fascia into intermuscular spaces. They are always invested with a thin, dry, fibro-cellular capsule, isolating, and yet connecting them with the surrounding parts, especially the skin; and partitions extending from the capsule separate their lobes. Their principal bloodvessels ramify in the capsule before passing to the lobes; and are most frequently derived from one or two trunks rising from vessels beneath the tumor. The laxity of the capsule often permits a fatty tumor to shift or slide from the place of its first growth to one lower down. Thus, one beginning in the groin may shift down the thigh; or from the perineum one may pass into the scrotum: facts of great use in diagnosis, since such changes very rarely happen with other tumors.

Fatty tumors come under treatment in young persons, and adults of all ages. They are very rare in children, but not rarely begin to grow in youth, though, growing slowly, they may be overlooked for many years; they may begin to grow at any later age, but very seldom appear first in old age. They are sometimes assignable to local causes, as a blow, or, more commonly, frequent friction, as by a strap or band over the skin. Sometimes, too, they have so appeared after fever or some general illness, as to seem due to a constitutional cause. But, in a majority of cases, no good cause can be assigned for them. From the first they present a perfect adipose structure; no changes of development are known in them. Their growth is commonly very slow, sometimes fitful, very rarely rapid; but, though slow in growth, they may grow long enough to attain an enormous bulk; some have weighed fifty pounds. They are usually insensible, yet are sometimes referred to as the centres or causes of vague radiating aches and pains. After injury, or sometimes spontaneously, they may inflame or degenerate. Of this, the most frequent consequences, and the most important to be remembered in diagnosis, are, central collections of serum or pus, or some glutinous fluid in a cyst; central nodular induration or calcification; sloughing or ulceration of the superjacent skin, and exposure of the tumor, a result which is especially likely to happen with such as are pendulous.

In a great majority of cases fatty tumors occur singly; yet instances are not rare in which large numbers of them appear in rapid sequence in the subcutaneous tissue of the limbs (especially the arms) and trunk, all slowly increasing, till, after attaining about an inch, or rarely more, in diameter, they usually cease to grow. Their multiplicity and general limitation as to size are the only characters distinguishing the tumors in this singular form of disease. In the times and conditions of life in which they may first appear; in the absence of all evident constitutional disease; in their varieties as to degree of firmness and amount of intersecting connective tissue; and in every other respect, they are exactly like the more common single fatty tumors.

Little need be added to the foregoing description to indicate the diagnosis of a fatty tumor. A firm deep-seated one may be not distinguishable from a fibro-cellular or fibrous tumor; but this is of little importance; it is enough to make out, by the uniform firmness, elasticity sometimes hardly distinguishable from fluctuation,

mobility, smooth, regular, or largely-lobed shape, by the slow growth, and freedom from pain, that the tumor is not a chronic abscess, cyst, bursa, or firm medullary cancer, but an innocent tumor, proper, if required, to be removed.

The diagnosis of the common subcutaneous fatty tumor is much more easy, and will seldom be missed if it be observed that, with most of the characters indicated above, a tumor feels soft, pliant, "pillowy," easily movable, and that, by compressing its base and borders, so as to make the skin tense over it, the skin presents dimples corresponding with the spaces between its lobes. Pendulous fatty tumors can be confounded with none but pendulous cutaneous growths; and the diagnosis is difficult but unimportant. The consequences of inflammatory and other changes will not make the diagnosis harder than usual, if the probability of their occurrence be kept in mind. Multiple fatty tumors have nothing like them, except the neuromata or fibrous tumors that sometimes occur in great numbers in subcutaneous nerves; but these are generally much firmer, more variable in size, often painful, and are associated with other and deep-seated tumors.

Only one method of treatment, excision, is applicable to fatty tumors. It is to be recommended for any that are unsightly, or inconvenient by their bulk or hindrance of movements, or increasing so quickly that delay of the operation will materially augment its extent. In the excision it is usually sufficient, and advisable, to cut fairly, with a single median incision, into the tumor, and draw or scoop it out by splitting the capsule that loosely invests it. In the case of the multiple fatty tumors, removal is very seldom to be advised, unless for any one that may grow very far in advance of the rest. With those that are pendulous, all the covering skin should be cut away, except so much as may be necessary for flaps to close the subcutaneous part of the wound.

The prognosis of fatty tumors is most favorable. They may be removed with as little danger as attends any cutting operation whatever; they almost never return after removal; and small portions left in operations commonly fail to grow. In one case, however, after several removals of a fatty tumor, there was again a recurrence; and it was found that, with the fat, there was a large quantity of young and growing fibrous tissue in a stalk of the tumor which lay beneath the pectineus muscle, and which had in each operation been cut through.[1]

[1] Messrs. De Morgan and Hulke's Report on Mr. Curling's case, Pathological Transactions, vol. xviii. p. 186.

Fibro-cellular tumors and outgrowths are such as consist entirely, or chiefly, of tissue resembling the ordinary cellular, areolar, or connective tissue of the natural structures. In different specimens the tissue may be more or less embryonic or perfect, more or less delicate, or firm and tough, succulent or dry; or other tissues, as the fatty, elastic, or even glandular, may be mixed with it; but, in all these respects, the tumors scarcely exceed the differences which exist among different examples of the natural structures referred to the cellular or connective tissue in its various conditions of development or disease.

The most frequent of the outgrowths are found in the softer kinds of polypi, and in the pendulous growths of skin. These will be described in other appropriate places (NOSE, EAR, SKIN, etc.); but it may be observed of nearly all the so-called mucous or gelatinous polypi, that a very large part of their substance is composed of gland-structures; and of the cutaneous outgrowths, that not the fibro-cellular tissue alone, but all the component structures of the skin, are usually together, though not equally, increased.

Fibro-cellular tumors are among the rarer forms. Their most frequent, but not exclusive, seats, are the deep intermuscular spaces of the limbs, the scrotum, labium, or by the wall of the vagina, and (in the form which most closely connects them with the fibrous tumors) in the subcutaneous tissue. Their typical characters are best marked in those removed from the limbs, scrotum, or labium. They are usually oval or round, more or less deeply and largely lobed, invested with thin capsules of connective tissue, by the splitting of which they may be each separated or enucleated from the adjacent parts (a character by which those of the genital organs are at once distinguished from the cutaneous outgrowths and hypertrophies of the same parts). To the touch they are firm, tense, and elastic, very like tough-walled cysts tightly filled with fluid. On section they usually present a shining, pale-yellowish, or serous-colored basis, intersected by opaque white bands, moderately firm, succulent, and very elastic. The intersecting bands or marks are curved, but with no regular plan, and give no distinct fibrous appearance to the section. At first sight many of these tumors, soaked as they are, or, as it were, œdematous, with yellow serous fluid, look like fat; but when left at rest, or suspended, the fluid oozes from them, and their tissue contracting becomes firmer, whitish and opaque.

[The classification given by the author of the fibrous tumors differs entirely from that at present used by writers. It is easy

to distinguish under the names here used the kind of tumor indicated, but many which are here included under fibrous tumors are placed by other authors under different headings and even classes. The fibro-cellular and the fibrous tumors of Paget are spoken of generally by others as soft and hard fibromata; the glioma is made a separate division, or by some placed with the sarcomata; the myoma, although it may in some cases resemble a soft fibroma, cannot be confounded with it. The fibro-muscular has been differentiated from this group by Virchow, although the cells of the growing fibroma closely resemble the smooth muscle cells. We shall describe each of these classes of tumors according to the at present existing views held concerning them.

The fibromata consist for the most part of well-developed connective or fibrous tissues, and present in their structure the same variations as are met with in these tissues. These variations depend to some extent on the seat or position of the growths, and the tissue from which they originate. Thus, tumors of this variety growing in the uterus are generally firm and dense, while those from the skin are commonly loose in their structure, and more nearly resemble the connective tissue of the cutis from which they spring. On the other hand, their characters in respect to consistence vary or may be changed by the position of their growth. A fibroma growing from the surface of the skin may, as it protrudes and becomes pendulous, have the character of its fibres change by infiltration of serum, and that which formerly presented close dense interlacing or concentric grouping may become loose and spongy. Again, firm fibrous tumors may grow from tissue essentially loose in structure, as, for example, fibroma of the mamma.

Soft fibromata consist of very tough, rather œdematous whitish tissue, resembling that of the cutis. Histologically they are composed of loose connective tissue, resembling that of the cutis in conditions of œdema, although the fibres frequently present broader bands or a looser structure; fine delicate fibres closely woven are not absent. Bloodvessels are frequently large and abundant, and never rare, though they may be represented only by wide-calibred capillary tubes, around which proliferative changes are active. The surfaces of these growths, and they are generally surface growths, are covered by integumentary or mucous-membrane structures, of which the epithelial, hairy, and gland tissue exhibit hyperplastic conditions. Billroth says that almost always pointed papillæ occur on the surface of these tumors, even in places where the cutis is not normally covered with papillæ; on the other hand, there unquestionably occurs, as we have observed in these tumors, a smoothing out or obliteration of the papillary and other integumentary structure, due to an unusual protrusion or rapid outgrowth of these neoplasms. Another peculiarity frequently to be noted in these outgrowths as they occur on the skin is the deposit of pigment in the lower or lowest layer of the epidermis, by which the whole of the surface of the tumor becomes darkened in color, even several shades darker than the surrounding normal skin. This pigmentation is seldom found deeper in the tissue, and has not been noted on the mucous-membrane surface of these tumors.

The general statement is made rather loosely that these growths are generally found in the cutis, but it is doubtful whether they take their origin from the subcutaneous or submucous connective tissue. In the strictest sense, the connective tissue of these parts is a differentiated tissue, and whilst, as yet, embryological studies do not allow of our pronouncing positively, it is probable that histogenetically the sub-epithelial tissue of both the cutaneous and the mucous surfaces belongs not to the middle or connective-tissue layer, but to the epithelial, in the one case outer, and, in the other case, inner layers. If then the fibrous tumors are genetically related to the connective-tissue structure, the apparent origin so frequently seen of these growths *in* the cutis is only apparent, not real, and the relation of the cutis to these growths is one of blending and not that of origin. Billroth's observation, on which he lays stress, that the epidermal structures participate in the growth, would tend to negative this view, but his observation cannot be considered wholly correct, and cannot be held to support the cutis origin of the tumors, because in similar new growths taking place in the mammary gland, the acinous structures of the mamma become variously altered; although in this case there is no question of the origin of the growth from the periacinous connective tissue, and the new growth is not participated in, except accidentally, by the epithelium of the gland structure. These tumors are usually seen as diffuse outgrowths, loosely hanging and often well pedicellated. They are without capsules, or only acquire such coverings when by their weight they move from the seat of origination, and compress or condense the surrounding tissue.

The polypi of the mucous membranes, in the more contracted sense, are not to be classed as soft fibromata, for the principal mass of the tumor is formed of hypertrophic glands; they are covered by a continuous layer of cylindrical epithelial cells,

generally, in nasal polypi, ciliated in character; the gland ducts and vesicles are lined with cells, and their lumen is filled with tough mucous masses. In these tumors, besides the glandular elements, there exists a certain quantity of soft connective tissue, more or less rich in cells; this connective tissue concentres into a firmer fibrous mass to form the pedicle, which contains the bloodvessels, often abundant in amount. It is clear, therefore, that in such a mass we are dealing with a circumscribed hypertrophy of the mucous membrane, principally manifested in its glandular changes. The fibro-cellular tissue is an incident of the growth, necessary to the support of the glandular formation, but not the principal element of the neoplasm. We distinguish these polypi from fibrous neoplasms, not alone on account of their different constitution, but because of their different seat of origin. Here, as in the skin, the increase of connective tissue arises from the sub-epithelial tissue, and not from the true fibrous layer of the organism.

The molluscous fibroma, of which the author does not speak, has been included among the soft fibrous outgrowths, and is, as a rule, a multiple tumor. It takes its rise in the papillæ or even a single papilla of the skin, and may from this enlarge to an enormous size. The tissue of the papilla shows a growth of round or spindle-shaped cells, and these elements progress to the formation of fibrous tissue. This fibrous tissue never exhibits a compactness, and its interspaces are filled with fluid, as in œdema, and the tumor is always soft. A section of the new growth shows the same arrangement of the fibrous trabeculæ radiating from the seat of the original papillæ which produced the growth. The striking peculiarity of these growths seems to be the fact that the complete growth represents the greatest part of the original germinal tissue which was its foundation, and that the growth is an unfolding of this new tissue rather than the deposit of new germinal matter, which proceeds by the same steps of development to the enlargement of the growth. This method of growth differentiates fibroma molluscum very distinctly from other fibrous outgrowths or tumors, and allies it more closely to the hypertrophies or hyperplasiæ than to true tumor formation. Again, fibroma molluscum, like polypi, and for the same reason, is to be distinguished from fibromata in general, in that it is a growth from the papillary layer, and not from the true fibrous tissue of the organism.

For the same reasons that we have excluded polypi and fibromata mollusca from the class of soft fibromata, where they have generally been placed, we are led to exclude the congenital cutis proliferation, such as hairy nævi and the larger moles, as well as the keloids; these, on the one hand, are usually pigmented papillomata, and on the other are allied to sarcomatous growths (both true and spurious keloids). Likewise, elephantiasis must be regarded as an hypertrophy, and not as a fibroma.

We have therefore left in the class of true soft fibromata tumors which occur in great variety, as those in the deep intermuscular spaces, within the scrotum and labia, and in the subcutaneous connective tissue, and very rarely in any other situations, and that this variety of growth can be distinguished from the hard fibromata is very doubtful. It is probable that its soft condition is the result of a complication with œdema, caused by position or any general interference with local circulation, rather than an essentially different type of new formation.]

In microscopic examination the fibro-cellular tumors present the same elements as the similarly named and natural tissue, but, usually, with a larger proportion of them in a rudimental form. Generally there are, or appear, abundant fine colorless filaments in undulating bundles, variously interlaced or matted; and with these, are various proportions of nuclei, and of fusiform or caudate, or stellate nucleated cells, such as may be found more abundantly in granulations, or in the softer kinds of connective tissue, in which the connective-tissue corpuscles are most abundant. (See Figs. 36, 38, 39.) Occasionally, very soft examples of the tumors are met with, in which these corpuscles predominate over the filamentous tissue. In most instances, the elements of connective tissue are alone found in these tumors; and their varieties depend on the degrees in which these elements are developed, or variously compact, or infiltrated with fluid. Elastic yellow tissue is very rarely seen; a singular fact, if the almost constant presence of that structure in the natural connective tissue be considered. But, occasionally, nodules or thin layers of cartilage or bone are found, either embedded in, or encasing the mass of the tumor, adding not a little to the difficulty of the diagnosis.

The origin of a fibro-cellular tumor is very rarely to be traced. They are so seldom referred to violence, inheritance, or any general disease, that when they do seem to have such an origin, it is, probably, only by a chance-coincidence. They may begin to grow at any period of life, but they do so most rarely before adult age, and most frequently at middle or older age. Their rate of growth is variable, but sometimes very rapid, as much as three or four pounds in the year;

or even, as Mr. Paget saw in one case (which however, was an instance of recurrent tumor), at the rate of a pound per month.[1] Thus, or more slowly increasing, they may attain a weight of forty or more pounds, especially in the scrotum, whose texture offers them the least resistance, and, by its extensibility, and quick growth, the best protection. The extreme distension, however, which such tumors cause, often leads at last to sloughing or ulceration of the integuments over them, especially at their lowest or most dependent part. The ulcer, in these cases, presents no specific characters; and the tumor usually only lies exposed at its base, without protrusion; but the purulent discharge and increased irritation to which the change gives rise, being added to the burden of a huge tumor, may prove fatal. The tumor may partake of the changes of the parts over it, becoming inflamed, soft, or sloughing; but in these changes resembling only the ordinary connective tissue, when similarly diseased. Except in these morbid states, the ordinary fibro-cellular tumors are very rarely painful.

The statements just made respecting rapid growth, sloughing, and ulceration, apply to the fibro-cellular tumors of the external genital organs, much more than to those of any other parts. And corresponding differences must be had in view in making a diagnosis, during life, of any example of this form. In the scrotum, it may be difficult to diagnosticate a fibro-cellular tumor from some disease or growth in the testicle; and here the chief point to be looked to (in addition to those already mentioned in the description of the tumor), is the separateness of the testicle from the new formed mass. If the testicle be free, the nearest likenesses are in large omental herniæ; in fatty tumors in the scrotum; in hydroceles; in elephantiasis scroti. It must suffice to enumerate these, for no single sufficient ground of diagnosis can be stated; and the discrimination must, in each case, be made by comparing the characters of the disease under examination with those of each of the several diseases above named. So also with fibro-cellular tumors in or near the labia; the diagnosis is to be similarly made from large labial herniæ, from Cowperian cysts, from fatty tumors, and from cutaneous outgrowths. In the subcutaneous and intermuscular tissues, the most nearly similar diseases are chronic abscess, hydatid, and the several forms of tumors of the softer kinds, as the fatty, cystic, medullary, and others. Happily, a nearer diagnosis is important for the cancers only, since all the other confusible swellings are such as may properly be cut into or cut out.

Excision is the only proper treatment of the fibro-cellular tumors, and it is to be advised in nearly every case, unless in those of old people, in whom the growth has attained such a size that its removal would be too dangerous to life. What has been said of the excision of fatty tumors might be repeated here; and so might the statements as to the very favorable prognosis after removal; but with this reserve, that if a fibro-cellular tumor be very incompletely developed, soft, looking like little more than size or other soft gelatine, or presenting a great preponderance of its elemental structures in an embryonic state, it is likely to prove recurrent.

Among the most remarkable tumors formed of fibro-cellular tissue are some of those named "painful subcutaneous tubercles." But inasmuch as the pain, which is their chief characteristic, may exist with tumors of other structure, there will be some practical convenience in describing them at the close of the essay.

Closely allied with these is the mucous tumor, or myxoma, of Virchow. (See Figs. 39, 58). It resembles the loose gelatinous tissue, named mucous, which composes the substance of the umbilical cord, and is found in adults in the moister and soft connective tissues, and in the vitreous body of the eye. From such tissue the myxoma is derived, as the fatty tumor is from adipose tissues, and the fibrous tumor from fibre. Myxomas are sometimes remarkable for the looseness of their build, and for the freedom with which on section their substance will trickle away in thick gelatinous strings. In their simplest form they present no other character than this, as in the eye, or in the brain, where they spring from the neuroglia. Sometimes, however, they are mixed with other textural elements, and grow (as we have seen in the septum of the nostrils) into a gigantic tumor, in which bone and cartilage are irregularly mixed with mucous tissue, no denser or more capable of supporting its own weight than is the corresponding slimy substance of the hydatid mole. They also form in the connective tissue of a thigh, or of the neck near the angle of the jaw, in that of the nerves, the subcutaneous tissue, or in the breast. They have also been met with in the jaw. They may be removed by the usual operation in suitable cases, but those in the eye require,

[1] It should be mentioned, however, than in these, as, in a less degree, in other tumors, there may be much increase of size without so much growth; for their bulk may be augmented by serous infiltration, or inflammatory deposit, or other causes of mere *swelling*, without growth.

like the other disorganizing tumors, extirpation of the globe. After complete removal they are not liable to return.

[The *mucous tumor* or *myxoma* (Virchow) is a morbid product composed of mucus or mucous tissue, as it is commonly spoken of, and which imparts the distinctive characteristics to the new growth. Tumors of this variety have a yellowish or yellowish-gray, reddish-white, or greenish color, differing somewhat according to the tissue in which they develop, although the seat of growth is not absolutely determinative of their color, as accidental conditions, such as blood, or fatty changes occurring in the tissues of the tumor, exercise a stronger influence on the color than any other factor. They are always of jelly-like consistence, and, if of sufficient size and isolated, tremble to the touch, are elastic, sometimes œdematous and pitting, and vary greatly as to firmness, and commonly lobulated. On section, a mucilaginous fluid escapes, which varies considerably in tenaciousness in different specimens, in some thin and flowing easily, in others thick and ropy, and again in others more like lumps of jelly. The surface of the section in the smaller pure myxomata appears nearly uniform, or, perhaps, presents a polygonal mapping out by lines of fibres invisible to the naked eye; in the larger ones the tissue is partitioned off into large or small areas or compartments by bands of fibrous tissue varying greatly in width and density. In the largest growths, the whole mass of the tumor is divided up into globular masses, and the whole inclosed in a thick capsule. From the general capsule, as well as the capsules of the individual nodules, fibrous trabeculæ are given off, which penetrate the tumor as well as its lobules, and these trabeculæ are seen on cross section as intersecting, radiating, or parallel bands of fibrous tissue.

The great bulk of the material, which flows or is scraped off the cut surface, is a nearly transparent and homogeneous material which yields large quantities of mucin. Besides this material a varying number of blood corpuscles, forced from the vessels of the growth, are seen together with cells of various forms, whose characters are best studied in sections of the tumors.

The structure of a myxoma is usually described as consisting of a mesh of capillary vessels in whose walls are seen the nuclei and the outlines of their endothelial cells. In the vascular interspaces is the mucous tissue, in which exist the characteristic cells, multangular and spindle-shaped, with long processes connecting them with their fellows, or, as more frequently seen, simply ending in the mucous interspaces; towards the periphery of the tumor the cells are more abundant and more regular in shape, and the processes derived from them connect with fibrous trabeculæ or with the enveloping capsule. These cells have indistinct outlines, and may contain one or more nuclei. Besides these cells, there are others contained in the mucous material and unconnected with fibres, of a round or oval figure, varying considerably in size, generally without nuclei, though in the larger ones these bodies may be present. The smaller ones resemble the white blood-corpuscles, the larger the wandering connective-tissue cells. Elastic fibres are to be seen, but no nerve fibres or lymphatics are spoken of by any author as being present; the latter structure, however, we have seen in the main fibrous partitions of an enormous myxomatous growth (39 pounds) from the connective tissue of the posterior abdominal wall.

Of the individual elements of the growth, some writers speak of the blood-vessels as abundant, others as scanty. Thus, Green says, the bloodvessels are not numerous. Rindfleisch, from original investigation of a myxoma of the cheek, as large as a fist, by the injection method, concludes that the capillary supply is poor, and that only large vessels occur running in the coarser partitions. Gross and Cornil and Ranvier both give prominence to the amount of the capillary meshwork. From our own investigations, the condition has been seen to vary not only in different tumors and in those of different size and age, but also in different lobules of the same growth. As the growth of these tumors progresses, unquestionably there may take place a relative lessening of their vascularity. No one has shown a distinct tendency to vascular outgrowth, but all investigations point rather to an expansion of the pre-existing vessels of the part. Again, vascularity is never marked, and in some instances is wholly wanting, in the myxomatous changes occurring in pre-existing morbid growths.

Development.—In speaking of the development of myxomata, there are two things especially to be borne in mind, first, that it is physiologically represented in both the fœtal and adult conditions, and is therefore a thoroughly independent and vitalized constituent of the connective-tissue series. In the adult we find it in the vitreous humor; in the fœtus, in the umbilical cord, and in all the embryonic connective tissues, especially those which later, by preference, receive a deposit of adipose material. Secondly, that very many of the fully developed members of the connective-tissue series may, by degenerative processes, become con-

verted into mucous tissue, or, more strictly speaking, tissue having its interspaces filled with fluid containing mucin. We see this process in the mucoid softening of cartilage and bone, of adipose tissue (of which especially good examples may be found on the pericardial surface of the heart in conditions of emaciation), and of areolar connective tissue.

The seat of origin is always from some member of the connective-tissue series. They arise especially from the adipose cellular tissue, either superficially or between the muscles, from the connective substance of the nervous system, from cartilage, or from bone. It is just here, in connection with the seat of origin, that we must consider the question of the essential nature of these growths. That they are tumors in the sense in which this word is applied to many masses which appear as morbid products, we have no wish to deny. But in all the tumors, except perhaps the cysts, we recognize cells having a more or less definite arrangement as the essential characteristic of a tumor. Now, in a myxoma, what are we to look upon as the essential characteristic of the neoplasm; is it the cells or is it the mucous material? The cells, from their appearance and description, are typical cells, having *none* of the atypical characters recognized in the cells of all other morbid growths, even the lipomata. Thecells are the same as those of connective tissue, and they show no tendency as cells to proliferate or reduplicate themselves. The mucous tissue is formed from the cells, not exactly as a secretion, but similarly to the fibres as produced by the connective-tissue corpuscles. That this material cannot be carried in from without is shown by the fact that from its colloid nature it cannot pass the blood-vessel walls, and probably with equal certainty and for the same reason cannot be carried away. It would seem, therefore, that these mucoid masses must be looked upon as the results of degeneration, rather than as new growths, and that they are tumors only in the sense of their having a given bulk, which has been produced by the imbibition of fluid and not by the proliferation of cellular elements.

Situation.—These tumors grow from the connective tissues, and therefore may be found wherever this tissue is present. There is a tendency for them to develop from the adipose tissue, and hence they occur with especial frequency in situations where fat ordinarily preponderates. Thus, the connective tissues of the neck and face, of the external genitals of women, of the thigh and back, furnish the larger number of instances of these growths; the nervous system and the bones furnish a small number; they grow also from the connective substance of the large glands, as the parotid and mammary. We have examined a large growth, already mentioned, from the connective tissue of the abdomen. They have been found in the scrotum, the cheek, the axillæ, and the testicle. The uterine moles and certain forms of nasal polypi, as well as polypi from the mucous surfaces, furnish other instances; occasionally, the mucous tissue of the umbilical cord gives rise to these tumors.

These growths found in connection with the nervous system always arise from its connective tissue. In the brain, they occur both as diffuse masses or in the form of rounded tumors, and in these cases usually have a greenish color; it is from the neuroglia that they spring. In the peripheral nervous system, they arise from the perineurium, where in rare cases they occur as multiple tumors developing at various points along the course of the different nerves. It is a striking fact that in these cases the nerve tubules show a marked power of resistance to the invasion of the growth or the effects of its pressure. Occasionally these growths extend to the spinal dura mater, and in the case of those in the brain, to the cerebral membranes, and to the optic nerves. In the osseous system they develop not rarely from the medulla of the long bones, but frequently from the short or flat bones, and in these cases are connected with the periosteum.

In the mammary gland, this form of tumor, in comparison with other morbid growths, occurs, in its pure form, with great rarity. S. W. Gross records only ten instances of the myxomata occurring in the mammary gland.

Myxomata are classed into various species, according to the predominance of one or the other of the normal constituents. M. hyalinum are those in which the mucous tissue predominates. M. medullare, in which the whole tumor or some portions show a preponderance of cells, and have a whitish, medullary appearance. Either of these forms may be lobulated. Myxomata exhibit combinations with the tissues of other growths, as M. fibrosum, M. cartilaginosum, M. sarcomatosum; probably these combinations should more properly be called fibroma, sarcoma, and enchondroma myxomatodes. A more frequent combination is with lipoma, or perhaps more correctly with adipose tissue (L. myxomatodes or myxo-lipoma). The combination with adenoma we see in the ovary. Klebs considers that most of the ovarian cystoids are produced by the development of the mucous fluid (myxoma) in combination with an adenoma of the ovary. This connection is also seen in nasal polypi.

A form of this tumor occurs which is markedly vascularized, and has received the name of M. telangiectodes. Moore has recorded such a case in the mamma, from which profuse hemorrhage occurred. Specimens where a new formation of vessels has taken place (true M. telangiectodes), and those in which hemorrhage and consequent staining of the mucoid tissues have taken place, have been only imperfectly distinguished by writers. Myxoma cystoides forms a variety due to complete softening and disintegration, from fatty degeneration, of both the cellular and the mucoid tissues of these growths, and in which, consequently, the contents have become markedly fluid.

The diagnosis of these growths is extremely difficult, and their general features are far from characteristic. The slow, though continuous growth which they usually exhibit, the peculiar soft elastic feeling, the mobility in relation to the skin and the underlying tissues (though not always present), the absence of pain (except from nerve pressure), the freedom from involvement of the neighboring lymphatic glands, are all to be noted in connection with these growths, but fail to distinguish them from other tumors.

Myxomata must be looked upon as non-malignant growths. That they produce death directly, either from the organs in which they are situated, for example, the brain and spinal cord or their membranes, or from their enormous size when in other situations, is true, but they show no tendency to the metastatic involvement of other organs, a feature so constantly observed in malignant growths. They frequently exhibit a very obstinate tendency to local return after extirpation, and this peculiarity does not seem to be due so much to any failure in the thoroughness of the operative treatment, as to a persistent and inherent tendency of the surrounding connective tissue, and this condition is more striking when the original tumor is developed from adipose tissue. This condition is looked upon by some as similar to that shown by certain lipomatous tumors, by others as due to the formation not of a simple tumor but of a lipoma myxomatodes, which is regarded as more malignant in its nature. Pure myxomata show less tendency to return than the mixed growths.

The successive appearance of myxomatous growths, for example, at two points on a nerve or on two different nerves, has been looked upon as evidence of its metastatic or malignant character, but probably incorrectly. Such instances are merely examples of a similar degeneration of the perineurium occurring at two distinct places at different dates.]

Passing by Virchow's *Psammoma*, or tumor containing sand, which is limited to the choroid plexuses and dura mater, and the syphilitic gummy tumor, lupus, elephantiasis Græcorum, glanders, and farcy, which he groups with the title, *Granulation-tumors*, we refer to another of Mr. Paget's group of fibro-cellular tumors, to which Virchow has given a specific name, *Glioma* (see Fig. 38), from its originating in the neuroglia or delicate connective tissue of the nervous system. It is a disease of the young, and comes before surgeons only when it grows from the retina or the perineurium of the cerebral nerves. In the eye it slowly forms a tumor which may grow to a considerable size. It may advance inwards into the vitreous body, or, detaching the retina from the choroid, may invade the outer tunics and protrude from the globe. (See DISEASES OF THE EYE.) Some of these tumors are soft and resemble the myxoma, or even the medullary disease, whilst others by their hardness are allied to fibrous tumors. On section, the glioma is vascular, and may be translucent, bluish white, or pinkish gray. Though connected with nerves, there is no nervous element in a glioma, but cells, nuclei, and an intercellular substance. The cells are sometimes small, and their anastomosing offshoots delicate: at other times both cells and offshoots are large. The intercellular substance also varies in development and in toughness in different tumors. Parts of a tumor may be found in a state of fatty and earthy degeneration.

These tumors come not unfrequently to operation in ophthalmic practice. They require the complete extirpation of the globe, and, if their cells do not exceed the size of those of the connective tissue of the retina, they are not likely to recur. Gliomas beset with cells of a larger size are apt to become malignant.

Fibrous tumors and outgrowths (see Figs. 32, 34) are among the most common kinds, including, as they do, those that are so frequent in the uterus, and others like them in that the fibrous is the most abundant but not the only tissue. Among the various names (desmoid, chondroid, tendinous, fleshy, and others) by which they have been described, "fibrous" may be chosen as implying their general likeness to the natural fibrous (tendinous or ligamentous) tissue; and where other tissues are combined with it, their presence may be indicated by compound names, as fibro-muscular, etc.

The fibrous outgrowths or polypi of the uterus, nose, pharynx, and other parts, will receive sufficient illustration in the

essays on the surgery of the several organs they affect.

The most frequent seats of fibrous tumors are the uterus; the bones, especially of the jaws; the nerves, where it may be impossible to distinguish the fibrous neuroma from that composed of nerve-elements; the subcutaneous tissue; the cellular tissue near joints, and many sheaths of tendons; the testicles; and the lobules of the ears. [In this country, fibromata in the lobules of the ear occur with great frequency in the negro race, following the piercing of the ears for earrings; it has been supposed that the brass of an inferior sort of jewelry is the common source of irritation leading to these growths. Whether it is that the negro wears a more irritating ear-ring than the white, or whether the growth develops more readily, as keloid certainly does in the black race, is an undecided question.] In all situations they tend to the rounded, oval, or true spherical shape, but adapt themselves perfectly to the shapes or resistances of the parts around them. Except in the uterus, and when connected with the jaws, they are rarely lobed. They usually are distinctly invested with a thin capsule, which, except in the nerves and bones, may be easily split; but those that grow on the exterior of bones are firmly connected with them, less or not more easily separable than is periosteum, and appearing, indeed, more like overgrowths of periosteum than like the distinct fibrous tumors of other parts. Their substance is usually very firm, resistant, elastic, tenacious, in some specimens intensely hard; in some, but probably through decay or inflammation, softer, brittle, œdematous.

[*Fibrous tumors* of the author are called by others hard fibromata. These tumors present, microscopically, a connective or fibrous tissue similar to that seen in tendon; the fibrous bundles run in various directions, frequently interlacing, and sometimes arranged concentrically. In the same manner as in physiological fibrous structures, there are found between the fibrillæ cellular elements, the so-called connective-tissue corpuscles, and these elements are at times richly developed. They are mostly small, oval bodies, with a shining nucleus; besides these there are seen not infrequently, especially in growing fibromata, rows of spindle-cells running through the tumor in various directions, and also foci of germinal matter, or simple nuclei sprinkled into the continuity of the fibres. It is probable that the very earliest stages of the growth of a fibroma exhibit a mass of indifferent germinal matter, which later is differentiated into spindle cells, and finally the greater mass of a fibrous tumor, at its completest stage of growth, shows tissue scarcely, if at all, to be distinguished from tendon, except in the irregularity of the arrangement of the fibres. Just as in tendon, so here, it is difficult to see the connective-tissue cells placed at intervals among the fibrillæ. The difference between the soft fibrous growths and the hard fibromata seems to consist in this: in the former all the elements of soft connective-tissue are represented—elastic fibres, some adipose tissue (probably a residue of the normal fat of the part), and the serous fluid always present in the normal connective-tissue interspaces; and these elements have the same confused arrangement which we see, for example, in the subcutaneous connective-tissue. We may, therefore, view these soft growths as an hypertrophy or hyperplasia of the normal tissue. In the hard fibroma, which has its physiological prototype in a different species of connective tissue, viz., tendon, the morbid growth presents an arrangement of its textural elements quite different and more irregular than the tendon, and on the whole it gives the impression of a formation unlike the "fixed appearance" which is defined as normal. However, these two species, easy to separate into classes by words, are found to shade into one another by insensible gradations, and the two are to be viewed, to express it briefly, as growths, the one having more serum disjointing and separating its minute elements than the other, rather than having a different embryological force for their causation, or belonging to different species.

It is particularly necessary to attend to the minute structure of tumors classed as hard fibromata, and to know intimately their appearance in their earliest stages of growth, because, since Virchow established the class of *myomata* and pointed out that a very numerous class of fibromata, viz., the uterine, are not really fibrous growths, but in truth muscular growths, composed of unstriated muscle cells, all so-called uterine fibroids have been claimed by many subsequent writers as myomata. Now while it must be admitted that a very considerable number of firm uterine tumors are myomata, yet it is equally true that a true fibroma grows from this organ. It must be admitted that nearly all solid tumors of the uterus, probably all that have reached the size of the fist, show by microscopic examination a structure precisely similar to that of true fibromata, and that, so far as these tumors are concerned, we are not in a position to determine whether they started as fibrous or as muscular growths. If they were muscular in their inception, by the time they have reached a larger size the compacting of their tissue has destroyed the typical appearances of the spindle-formed

muscle cells with their rod-shaped nuclei. It is also true that uterine tumors of large size yield a glue-forming substance characteristic of fibrous tissue; whether pure muscular tissue at all stages of development will yield a similar substance is not yet determined, so that chemical investigation is unable to assist in the solution of this problem.

Certainly very many of the smallest-sized tumors found in a uterus in which the large so-called fibroids are present—even tumors not larger than a pin-head, which we have personally investigated, show none of the typical appearances of a myoma, but unquestionably were fibromata.

It must be remembered, however, that size is not necessarily absolutely indicative of the age, and while no very large tumor can be young, on the other hand a very small one may be old, and merely have ceased growing before it had attained great bulk. Many of the small tumors which we have investigated furnished other evidences of their youth besides their dimensions; they showed a richness of growing cellular elements. Others, however, were nearly pure fibres, resembling the larger tumors, and were unquestionably instances of arrested growth.

The failure to distinguish clearly between a young fibroma and a myomatous tumor arises from a disregard of the germinal condition of fibrous or connective-tissue growths. Every connective-tissue new-formation exhibits in an early, but not its initial, stage a spindle-cell tissue, and it is just this tissue, which, as Rindfleisch remarks, is so difficult to discriminate from the spindle-shaped cells of muscular tissue, and thus many have undoubtedly been led astray, and have hastily assumed that every tumor growing in the uterus which exhibits a spindle-shaped cell is a myoma.]

On section, the fibrous texture is, in different specimens, variously marked. In some, curved, shining, white bundles of fibrous aspect traverse a more homogeneous basis-substance of grayish, yellowish, or dull-white color; in some, such bundles affect a kind of concentric plan, like that of an intervertebral fibrous disk; in some, bundles much less regular and distinct are, as it were, closely fitted together; in some, the whole section looks nearly uniform, pale or white, very dense; and the fibrous structure, though discoverable with the microscope, is not visible to the naked eye. In agreement with their other resemblances to the natural fibrous tissues, these tumors are very lowly vascular, though, when inflamed, capable of a greatly increased supply of blood.

[Fibrous tumors are liable to become filled with blood in large parts or even the whole of their extent; this results from a telangiectatic dilatation of the vessels ramifying in their substance.]

In the history of fibrous tumors, their origin usually appears spontaneous; that is, it is unknown. They may sometimes be referable to injury, but, except in the case of those that follow borings of the ear, which probably partake of the nature of cheloid disease, there is no general rule; and even when they can be traced to injury, there is no knowledge how or why the growth ensued. Their increase is usually slow in comparison with that of fibro-cellular tumors, and, since their growth seldom affects the adjacent parts so much as to interrupt their due and probably very slow nutrition, they may increase to an enormous size. Some, in the uterus, have been more than seventy pounds in weight. Generally, they grow uniformly, and without pain, unless they involve some sensitive part; and their growth, if not interfered with, is rarely attended with any cachexia or other constitutional disturbance; enormous fibrous tumors of the uterus are sometimes borne for years with no other damage than that of the burden. Accidents, however, may disturb this usual innocuity. If a fibrous tumor be inflamed, it may become very painful; may soften, or decay, and be excavated: if near the surface, it may give rise to ulceration of the integuments over it, may protrude and bleed even profusely. (With those of the uterus many other troubles may arise, which will be described elsewhere.) Besides these active changes in fibrous tumors, others of much slower progress may occur, of which the chief are the formation of cysts and calcification.

The cysts in a fibrous (or, as it may be called, "fibro-cystic") tumor, may be numerous, small, and scattered through its substance (this is frequent in those of the testicle), or one of large size may occupy all the mid-substance of the tumor, giving it the appearance of a thick-walled serous cyst, and admitting of similar treatment. [The cysts are the result usually of mucoid softening.] Fibrous tumors thus changed have been found in the uterus, and more rarely in the lower jaw. Calcification very rarely occurs, except in the uterine tumors, and its chief importance is that it indicates arrested or extremely retarded growth.

In all parts but the nerves and the uterus, in which there is no limit to the number that may grow coincidently, fibrous tumors are single.

The best marks for the diagnosis of fibrous tumors (excluding those of the nerves, testicle, and uterus, treated of elsewhere) are, their regularity of shape,

or their being moulded to surrounding parts; their uniform firmness or hardness; their generally slow growth and freedom from pain; the healthiness of the textures round them. To these characters may be added, for the diagnosis of fibrous tumors of the subcutaneous tissue, their mobility; their non-adhesion to the cutis, unless they be nearly ulcerating; their protrusion, and frequent bleeding when ulceration has taken place. In this tissue, the diseases with which a fibrous tumor is most likely to be confounded are, a single cancerous tumor, an indurated lymph-gland, a very tense cyst with thick walls, an unusually firm fibro-cellular or recurring fibroid tumor. From these last two a diagnosis before excision may be impossible. In the deeper parts, as near joints and by sheaths of tendons, the same general characters may serve for diagnosis; the most similar diseases being very tight and hard bursal or ganglionic swellings, firm medullary cancers, cartilaginous growths within or on articular capsules, or near the heads of bones.

On or within bones the diagnosis of fibrous tumors is scarcely to be made, except at the jaws, where, however, they are often mixed with myeloid. A growth resembling a fibrous tumor, connected with any other than a jaw-bone, is most likely to be either cartilaginous, myeloid, or a medullary or osteoid cancer. Those of the jaws may grow either on the surface or within the bone. Among those on the surface are the most frequent examples of epulis. Their best diagnostic signs are, their being hard; having the alveoli for their chief base of attachment; shaped to the mouth and other jaw; often comparatively narrow-based; slow in growth; painless; covered with healthy mucous membrane; or, if ulcerated, having no specific form of ulcer; not associated with any serious disease of the adjacent parts, nor, even when of long duration, with any cachexia or disease of lymph-glands. By these characters the fibrous tumor on either jaw may be distinguished from medullary and epithelial cancerous growths, and from myeloid tumors, and periosteal swellings—the only diseases likely to be confounded with them. And, lastly, for the diagnosis of fibrous tumors growing within and expanding either jaw-bone, the chief points to be looked to, in addition to those already indicated, are, their slow growth; the healthiness of the covering tissues, especially of the gums; the absence of signs of infiltration of the disease into adjacent bones, which, though they may be displaced, are not overspread. These signs may suffice for the diagnosis from cancerous tumors; but so long as the growth is not sufficient for a great expansion of the jaw, and for such thinning of the walls as may permit the detection by tact of the nature of the material within them, it may be scarcely possible to make a diagnosis between a fibrous tumor and a dentigerous or other cyst, or any other non-malignant interior or substantial growth.

The diagnosis of a fibrous tumor in the lobule of an ear is easy; cysts alone are likely to be confounded with it.

In the treatment of fibrous tumors (not including those of the uterus), excision is the only available remedy, and had better be resorted to without delay. The method must vary according to the seat of the tumor. Simple enucleation is rarely possible in those within the nerves, bones, or lobules of the ears, though in the first two it may be very often worth attempting, for the obvious advantages that would attend success. In the removal of those that grow on bones, the base from which they spring must be removed with them; and the probability of their dipping into alveoli or other cavities must be remembered.

After the complete removal of a fibrous tumor, recurrence is not at all probable, except in the case of those of the ear-lobules, which, as already stated, seem to partake of much of the nature of the cheloid disease of scars. But, before promising future immunity, the diagnosis from recurring fibroid tumor must be made sure even after excision; and this surety may not be obtainable without microscopic help. Moreover, cases have occurred, though in extreme rarity, in which fibrous growths have presented every character of cancerous disease except that of structure: recurring; infiltrating adjacent parts; growing in distant organs; destroying with cachexia. It is a question of words whether these should be called "malignant fibrous tumors," or "fibrous cancers;" and the question is dependent on another, namely, whether the structure or the characters of life should have precedence in determining the names of morbid growths.

Cartilaginous tumors, or *enchondromata* (see Figs. 31, 35), as they are almost as frequently called, occur most commonly in connection with the bones; but they are not rare in the substance or neighborhood of the parotid gland, or in the testicle; and they may be found as curiosities in the thyroid, in subcutaneous tissue and in other parts. Growths of cartilage, pendulous, or loose in joints, have also many characters in common with cartilaginous tumors; but their peculiarities predominate enough to justify their separate consideration.

The general characters of cartilaginous tumors are that they are irregular, or, if

of any definable shape, rounded or oval masses, which, if not restrained by resisting surrounding structures, have very generally well-marked, prominent lobes or outstanding smooth nodules. Usually, they feel everywhere hard, resisting, scarcely compressible; but when compressed, they give the sensation of very quick elastic recoil. Rarely they are soft and compressible, but still very elastic. On those parts which are not attached to or inclosed in bone, they are invested with tough fibro-cellular tissue, that serves them as a perichondrium, and this is again connected with the surrounding parts by similar tissue of much less compactness and peculiar dryness. The parts around a cartilaginous tumor are usually quite healthy; no growth seems to be more readily tolerated, or to displace other structures with less offense or injury to them. Only, if there be much friction between a cartilaginous tumor and the parts next to it, a bursal sac is commonly formed between them. When they grow within bones, the compact osseous tissue grows as a shell around them, with no intervening tissue, firmly but not inseparably adherent.

On section (and the sensation of cutting them is generally quite characteristic), a cartilaginous tumor may appear as a single mass, imperfectly partitioned; but as often it is like a cluster of tumors, separated by their several investing layers of connective tissue, though inclosed in a common covering. In either case, the most frequent appearance of the cartilage is like that of ordinary fœtal cartilage; bluish or yellowish-white, smooth and glistening, close, uniform, without appearance of granular or fibrous texture. Some specimens, however, without appearance of disease, are soft, almost diffluent; some are fibro-cartilaginous; some look granular; some are opaque or creamy-white; some are varied by partial ossification; some by degeneracy or disease, in ways that will be presently described.

The origin of cartilaginous tumors is sometimes by inheritance, and sometimes is referable to injury; but neither of these sources is frequent enough to help in diagnosis, unless in the case of the cartilaginous tumors of bones. With the exception of those growing in the bones of the hands, they are usually single tumors, but sometimes they are numerous, and distributed symmetrically. Those of the bones most commonly begin their growth in early life; some on the hands in infancy; others, more often, between childhood and puberty. Their beginning in later life is, however, not very rare, even on the bones; and in other parts they most commonly begin in full adult or middle age. Exceptions to these general rules are, unfortunately, frequent enough to detract from their value in diagnosis; but it may be generally held that the younger the age at which a tumor of bone begins, the more is it likely to be cartilaginous, if its general characters agree therewith.

Their rate of growth is entirely and inexplicably uncertain. Their histories would tell of increase, in some instances as rapid, in others as slow, as could be told of any of the most different tumors. Most frequently, indeed, they increase slowly; but the rule is too uncertain for diagnosis. So is the size they may attain; some have grown to enormous dimensions; for instance, two feet in diameter; others have gradually and slowly increased to less than an inch; but both these extremes are rare.

Coincidently with growth, ossification of a cartilaginous tumor may go on; or rather, while one part of the tumor is growing, another may be ossifying; and if, as often happens, the ossification be more rapid than the growth, the cartilaginous tumor may become wholly osseous. Such ossification is most frequent in cartilaginous tumors arising from bones, and the most frequent condition in which such tumors are found, is that of having bases or stems formed of cancellous bone and covered with a mass or crust of cartilage. The cartilage, once on the level of the natural bone, has been in fact lifted by its own ossification, and the tumor thus produced increases simultaneously in length and in distance from the primordial cartilage, whence it originally sprang. A similar displacement is sometimes noticed when a cusp lies on the side of the neck of a tooth, instead of on its crown. In the cartilaginous tumors that grow within bones, and in those of the testicle and other soft parts, the ossification is usually very sparing; only scattered little pieces of soft bone are found in them; but these are sometimes arranged as so many nuclei or centres of ossification, one for each constituent lobe or nodule of the mass.

By degeneracy, or defective development, or, still more, by disease, the characters of a cartilaginous tumor may be so altered as to make its diagnosis extremely difficult. The chief condition thus arising is a softening or liquefaction of the cartilage, so that nodules of it present central cavities filled with fluid, like honey, synovia or serum, or with semifluid jelly-like substance; or a large tumor may be excavated, and its central part may be occupied with these soft or liquid materials, round which its solid part remains like a thick nodular cyst. The nature of this change is uncertain; perhaps, indeed, in some cases, that which looks like softened or liquefied cartilage is a material arrested in a rudimental state, which had

never been developed into natural firmness; but, generally, softness coincides with rapid increase of the tumor.

[This mucoid softening is peculiarly frequent in cartilaginous growths, and is due to the fact that the tissue of the enchondromata, like that of normal cartilage, is nourished as a non-vascular structure. When the growth exceeds a certain size, the central parts are removed too far from their peripheral source of nutrition, and unless new-formed vessels arise, degenerative transformations must result if the growth continues to increase. A central spot of softening is formed, which extends, *pari passu*, with the extension of the peripheral growth of the tumor.

To this mucoid softening has been applied the name *myxoma*, and a subdivision of enchondromata, viz., enchondroma myxomatodes, has been erected, wrongly, as we think, because it implies that a new and different tumor-formation has been engrafted upon, and is going on side by side with the original growth, whereas, in fact, the myxomatous change is merely one of degeneration from lack of nutrition.]

With active inflammation the substance of a cartilaginous tumor may rapidly soften, as if with decay and suppuration. Thus, some are found excavated, with cavities full of purulent fluid and *débris;* and some, forming adhesions to the skin, may ulcerate and protrude. But even in this state they rarely bleed largely.

To the numerous varieties of appearance which may thus be presented by cartilaginous tumors, those must be added which are due to their being mixed with growths of wholly different kinds. No "mixed" tumors are so frequent as those of which cartilage forms part. Thus, nodules of cartilage are not very rare in fibro-cellular tumors; the cartilaginous tumors in or near the parotid gland have commonly an intermixture of glandular tissue; many of those in bones are mixed with myeloid structure; and, in the testicle, cartilage often occurs in an apparently single tumor with medullary cancer [sarcoma, frequently alveolar sarcoma], and sometimes, according to Virchow and De Morgan,[1] it becomes cystic, multiple, and disseminated.

The varieties just described interfere with general rules for the diagnosis of cartilaginous tumors; yet some may be stated. When they are not encased in bone, or in unyielding tunica albuginea, they may be almost always known by their extreme hardness, their peculiarly round or nodular surface, and their quick resilience if they can be compressed. Their hardness may be equalled, though not resembled, by that of scirrhous cancer, of bone, and of a calcified structure; *e. g.*, a lymph-gland filled with calcareous matter. But cartilaginous tumors are so exceedingly rare in the breast, and single scirrhous cancers are so equally rare in any other external organ, that doubt between these two diseases can scarcely ever arise. The difference in kind of their several hardnesses will distinguish cartilage and bone, unless there be much thickness of soft parts over them; but, indeed, in any case in which a doubt exists, it is probably not important whether the tumor be cartilage or bone, or a mixture of the two. And, for the diagnosis between a cartilaginous tumor and an indurated or calcified gland, it may usually be found in that one does, and the other does not, grow.

Next to these signs for diagnosis, the most important may be the situation of the tumor. If it be in or upon the parotid gland, and possess the tangible characters of a cartilaginous tumor, pure or mixed, in but a moderate degree, the probability of its being such a tumor is very great. The other diseases likely to imitate it are simply enlarged lymph-glands, or cancer in the parotid or in its lymphatics. The diagnosis between the first and a cartilaginous tumor can scarcely be difficult; from cancer, one may be most generally known by its special form, its freedom from adhesion, its failing to injure the portio dura, its singleness, and its slow growth (for in this region cartilaginous tumors do not at all equal cancers in their rate of increase).

The diagnosis of cartilaginous tumors of the testicle and in connection with bones will be treated elsewhere.

In the treatment of cartilaginous tumors, removal is the sole remedy; but its method must vary with the seat of disease. In the parotid region enucleation may be unexpectedly difficult, through the proximity of branches of the facial nerve, the free hemorrhage, and the frequent dipping-in of lobes of the tumor to deep regions. The difficulty, if foreseen, is very rarely insuperable; but if any small portion of the tumor cannot be safely removed, it may be left with a good probability that it will not increase. For the tumors of the testicle enucleation is not to be thought of; but for those growing within bones it is more often practicable than practised, and may frequently be adopted; but on this point also see the essay on DISEASES OF BONES.

The prognosis of cartilaginous tumors after removal is generally very favorable; but some exceptions must be made. Such as are very soft may be recurrent; such as are mixed with cancer do not prevent the ordinary progress of the cancer, which

[1] Pathological Transactions, vol. xx.

affects lymphatics and distant organs, just as if no cartilage had existed with it in its primary seat. And, lastly, one case, recorded by the writer, has shown that a cartilaginous growth may pass into lymphatic vessels (probably by penetration of their walls), and extending along them into a vein, may yield to the flowing blood materials from which cartilaginous tumors may grow abundantly in the minute branches of the pulmonary artery.[1]

[*Osteoid-chondroma.*—There is another variety of cartilaginous tumor which requires special mention, viz., the osteoid-chondroma. This growth was first pointed out by J. Müller, but it was Virchow who first described its structures and showed its analogies.

They begin their development between the periosteum and the surface of the bones; the tumor is commonly placed around the bone, especially the extremity, assuming an enlarged spindle form, and very often attains a very considerable size with rapidity. It resembles bone rather than cartilage.

It has been supposed by Cornil and Ranvier, and Green, following them, repeats the statement, that these growths resemble the developmental process seen in rickets, but there does not seem to be any reason for this analogy. In histological characters they correspond very closely to the bone cartilage and its ossification, as seen especially in the flat bones.

In the earliest stages of the neoplasm, a foundation is laid as for normal bone, which, after the calcareous salts are deposited, is genuine bone; it is like the tissue which forms the greater part of the so-called callus deposited around the end of a fractured bone.

The cells of the growth are smaller than ordinary cartilage cells; and they are generally without the capsules which are seen in this tissue. They are to be distinguished from connective-tissue corpuscles by their uniformly rounded shapes. The cells rest in a matrix which is faintly striated or perhaps fibrillated. It is this matrix which becomes calcified, possessing trabeculæ and medullary spaces, confused in their arrangement and hence unlike true bone, as seen in simple osteomata; the growth is unlike other osseous tissue also in that it does not possess the ordinary bone corpuscles, but the cartilage cells, which form a delicate framework through the osteoid substance and by their further growth and development continue the enlargement of the atypical or neoplastic bone formation.

This tissue, like callus and its other analogues, is highly vascularized, the cartilaginous and osteoid trabeculæ giving ample support and protection to the abundantly ramifying vessels. In this respect it is greatly distinguished from ordinary enchondromatous growths, and for this reason not liable to the retrograde metamorphosis usual to them. Ossification more or less complete is their only change, and this process is not, probably, to be regarded as a degenerative one, as it so commonly is in the soft growths as well as in other morbid products.

Although this variety of tumor has been long known, and a very considerable number of instances are recorded of it, still its life history and diagnosis, and the prognostic indications in relation to it, have not been definitely settled. Billroth does not find sufficient reasons from any of its features to separate it from the sarcomatous growths. Others ally it more closely to osteoid tumors, and others to the enchondromata. It would seem from a comparison of all the cases recorded, that from its size it possesses great destructive power, and from its situation, most commonly occurring in the femur and humerus, that the only operative treatment to which it is amenable is very liable to be followed by death. In the cases which survive the immediate effects of the operation, there would seem also to be a great tendency to recurrence and to metastatic formations—greater than in the enchondromata, but perhaps not exceeding the sarcomatous growths to which this tumor bears a resemblance.]

Myeloid tumors.—[The myeloid tumors will be spoken of under Sarcomata. They belong to the class of giant-celled sarcomata.] (See Fig. 30.) They are distinguished by their containing or being chiefly composed of minute structures, similar to those of fœtal marrow or diploe. Unlike the cartilaginous tumors, in which the resemblance to fœtal structure exists alike in the plainly visible and in the microscopic appearances, these have no distinct resemblance to fœtal marrow in their general characters, though with the microscope the homology is evident.

The myeloid tumors affect especially the bones; and it is not yet certain that they ever occur as primary growths in any other structure; though tumors much like them have been found in the breast and other parts. At any rate their general characters must be described after specimens connected with bones.

Like the fibrous and cartilaginous, a myeloid tumor may grow either within a bone or on the surface of one; unlike them, it is more frequently found as an interior growth. In the general plans, places, and methods of growth, the myeloid are very like the fibrous tumors, af-

[1] Medico-Chirurg. Trans. vol. xxxviii., p. 247.

fecting generally the same shapes, and similarly displacing, but rarely otherwise damaging, the surrounding parts. When not encased in bone, they usually feel firm, compressible, slowly resilient, and "fleshy;" very few are harder than these words imply; but some are much softer, easily broken, like ordinary granulations. On section, their most frequent appearance is that of an uniform grayish or yellowish shining substance, blotched or suffused with deep crimson, or pink, or blood-color. The range of varieties of appearance is very wide; and besides, partial ossification, with plates or bars of bone intersecting the tumor, is not rare; and cysts filled with serous or bloody fluids are, in the instances of large myeloid tumors, frequent. Indeed, it is probable that not a few cysts in the articular ends of bones are examples of myeloid tumors, in which cystic formation has led to the almost complete exclusion of the solid structure. They usually appear lowly vascular, even when they are very ruddy (for this tint does not depend directly upon blood in them), or when, as sometimes happens, they pulsate.

Myeloid tumors are seldom referable to any evident cause, such as injury, inheritance, or defective health. They very rarely begin to grow in early life, or in old age; most frequently between youth and middle age. Their growth is usually slow and painless. The structures investing them usually remain healthy, even when greatly distended, and when the mass within is degenerate or cystic.

In the diagnosis of myeloid tumors, the diseases most likely to be confounded are cysts, fibrous or cartilaginous tumors, and cancer, of bones. When the growth is external (and it is so very rarely except on the jaws), a fibrous growth is alone like it, and is sometimes mixed with it; and the distinction, if any be possible, may be in that the myeloid is softer, more elastic, and more vascular than the fibrous. But, indeed, this diagnosis is of little importance. When the growth is within bone, it must be very difficult to make any nearer diagnosis than that between myeloid or some other innocent tumor on the one hand, and cancer on the other. And for this, the chief facts are, in the usually slower growth of the former; its broadly rounded shape, and seat in the articular end rather than the shaft of a bone; the absence of glandular disease, and of all cachexia, even though the growth may have been three or more years in progress. On the other hand, softness to the touch; penetration of the thinned walls of a bone; the existence of cysts containing blood; great bulk; pulsation at any part not covered with bone—all these, which are more commonly signs of cancerous growths, may be found in myeloid tumors.

What was said of the treatment of fibrous tumors of bone might be repeated for the myeloid; and the prognosis is, usually, as favorable. Nevertheless, cases have occurred, exceptions to the general rule, in which secondary myeloid disease has been found in lymph-glands and in the lungs.

Osseous tumors.—(See Fig. 35.) Under this name, those tumors are alone included which are composed entirely of bone, whether compact or cancellous with marrow. When cartilaginous or myeloid tumors are in process of ossification, they are usually grouped with those of the same name in which no such process is observable; when the ossification is complete (which, however, happens only with the cartilaginous), the tumor changes its name to osseous. Moreover, many growths of bone have some affinity with osseous tumors, yet do not bear the name; just as there are local overgrowths of fat which are not named fatty tumors. Generally, none are called osseous tumors but such as are either disconnected from bones, or are connected with them by well-defined, and usually small, attachments, which grow, if at all, at a less rate than the outstanding masses.

Of such osseous tumors there are two chief varieties: the cancellous, and the compact or ivory-like. The former consists of a structure like the natural medullary tissue of bones, containing marrow inclosed in cancellated bone, and usually invested with a very thin wall or layer of compact tissue. The latter are composed entirely or nearly so, of hard solid bone, like that of the shaft of a femur, for example. The cancellous osseous tumors are probably always developed through cartilage; the compact or ivory-like are rarely so formed. Usually, in both we observe a close likeness between the bone and other structures composing them, and those of the bones on which they severally grow. Thus, with rare exceptions, such as grow on long bones have perfect marrow in wide cancellous spaces; those on the skull are very hard, and, if in part cancellous, they contain diploe; and those which are peculiar to the phalanges of the toes are formed of hard, finely-cancellous bone, just like the phalanges themselves.

The general account of the cancellous bony tumors can scarcely be more than a supplement to that of the cartilaginous tumors of bones; for in many, if not all cases, they are but different stages of the same disease. Therefore, for facts concerning the origin, most frequent seats,

apparent causes, etc., reference may be made to p. 261–2, and to the essay on DISEASES OF THE BONES. In regard to treatment, all that need be added to what is said at p. 263, is, that when a tumor is thoroughly ossified, it is not likely to grow fast or much; and that the cancellous osseous tumors are always external to the bones with which they are connected, so that excision, not excavation, must be the method for their removal.

The compact or ivory-like osseous tumors are very rare in connection with any bones but those of the skull; and here they occur in two forms. Some grow on the exterior of the bones of the vault of the skull, in smooth, spheroidal, or lens-shaped lumps, attached, commonly, by rather narrow bases. Others, which are usually of deeply-lobed, and nodular shapes, grow in the diploe, or the frontal or other sinuses, whence, as they enlarge, they project through the gradually thinned and perforated layers of bones that at first inclosed them. The former kind rarely increase to an inch in diameter; the latter may increase to many inches, and they commonly project into the cavity of the skull, as well as externally, or into the cavities of the orbits or any other adjacent parts.

The substance of both these forms of hard osseous tumor is true bone, compact, normally vascular, and generally having some small portions cancellous, or like diploe.

[*Osteomata* have been distinguished, according to their microscopic structure, as belonging to three varieties, viz., O. eburnata, compacta, and cancellata, and into two classes, according to their seat, viz., exostoses and osteomata or osteophytes. Of these, the eburnated or ivory-like variety are usually rounded in shape, composed of dense, compact, concentric layers of bone, having a very scanty vascular supply. Their surfaces are very hard and smoothly polished, and they most frequently occur as outgrowths from the bones of the skull, though also found in other situations, for example, the pelvis, scapula, and the toe. We have two specimens, one from the palate bone projecting into the mouth, the other from the frontal bone, growing into the orbit and displacing the globe of the eye. This is the least frequent of the three varieties.

The second variety resembles the compact formation seen in the diaphyses of long bones; the Haversian canals and canaliculi are much more irregular than in normal bone.

The cancellous osteomata are characterized by having large open spaces in their interior, surrounded and partitioned by bony trabeculæ. These spaces or cavities are filled, oftentimes, with material or tissue quite unlike that found in the medullary spaces of bone. They almost invariably grow from the epiphyses of long bones.

Nearly all true osteomes grow as projections from bones, and are called exostoses; the class of those developed in the soft parts or in organs have not received a special name indicative of their seat of growth. (Green speaks of the latter as osteophytes; but this term is too general in its signification, and has been applied to spiculated outgrowths from bone due to inflammatory disease.) These two classes are called also, respectively, homologous and heterologous osteomata. Exostoses either grow peripherally from the periosteum or from the articular cartilage, or are developed within the medullary canals; these last receive the special name of enostoses. The vast majority of instances of osteomata are of homologous character, and very few such growths occur in soft parts, which, by common consent can be considered as tumors. Still, examples of such growths do occur, and one case is recorded of an osteoma within a cerebral hemisphere. Not unfrequently, a true bony growth takes place in the soft parts, for example, the tendons, fasciæ, and muscles.

Of the exostoses, two varieties may conveniently be distinguished: 1. Those which develop from the periosteum, and are in their structure generally of compact tissue or even ivory-like consistence. They are generally low, broad, flat growths, connected with the bone by broad, flat bases, though occasionally they grow to large size and have, by their great development, a comparatively narrow pedicle. 2. Those which are found at the articular ends of the bone, and have a spongy structure. They very frequently have a narrow pedicle, and are covered by a thin layer of cartilage continuous with the articular cartilage. They are essentially outgrowths from the epiphyseal cartilage; the cartilage which forms their covering ossifies towards the central portions while it goes on developing peripherally. These growths near large joints are sometimes covered by bursæ communicating with the articular cavities, which, on being opened during operations, lead to unfortunate results.

Of the osteomata of the soft parts, two varieties are known. First, the true heterologous growths occurring in the eye, in the brain, in the lung, and in the penis. Tumors of this variety are very rare; they form round masses covered with a capsule, and have an independent existence like other well recognized tumors. Secondly, the long growths in the tendons and mus-

cles, most of which cannot be regarded as true tumor-formations. They are usually irregular in shape, and about their development hangs the suspicion of an inflammatory disease. Of these may be pointed out first, as having a nature most nearly allied to osteomata, those bony developments in tendons passing over joints, similar in character to sesamoid bones. Next come the bones developed in muscles which are subjected to constantly repeated slight blows or pressure; the so-called "drill-bones," mentioned by German writers as occurring in the deltoid muscles from the striking of the musket during drilling, or on the inner side of the leg in the cavalry soldier. These growths must be looked upon as products of a chronic inflammatory process with some added element, since such growths of bone take place in very few soldiers. The osseous growths found in the cranial and spinal dura mater and arachnoid membranes are probably of the same nature, and owe their origin to the constant pulsation of the vessels of these structures. Much more striking, and perhaps more common than the first, at least of this latter variety, though still rare, are the bony developments seen in extended groups of tendons near the point of their insertions. Some of these are of rheumatic origin, and are, therefore, clearly of inflammatory nature, and must be excluded from the class of tumors; some have the appearance of being of periosteal origin, and have been described by Virchow as discontinuous osteoma of the bones; other cases occur in which bone develops, not only at the insertion of the tendons, but extending to the muscles and fasciæ, so that many groups of muscles in the different members of the body become ossified, and the movements of various joints are greatly hindered or impossible. We have recently seen such a case at the Pennsylvania Hospital under the care of Dr. Hutchinson, and Lücke quotes a somewhat similar case by Ebert; both cases were attended with general constitutional symptoms.

Among new bony growths may be mentioned the general enlargements of certain portions of the skeleton. They occur not very rarely on the maxillary bones, but of their nature so little is known, that they have been excluded from this class of tumors, although, as Paget points out, their exclusion serves to illustrate the arbitrary boundaries given to nosological classification.]

The diagnosis of these extremely hard bony growths from any other tumors is rarely difficult. They could not, indeed, be distinguished from masses of cancellous bone covered with a compact layer; but these rarely, if ever, occur on the skull. And of other tumors likely to occur there, there are none that can equal them in hardness as well as apparent fixity, unless it be certain small cutaneous cysts, shrivelled and with calcified contents. A much greater difficulty of diagnosis is sometimes between the hard osseous tumors and certain circumscribed hard hypertrophies of the bones of the skull or face. The main contrasts with the hypertrophy lie in the circumscription of the tumor, the smoothness of its surface, the narrowness of its base, its greater height or projection, its comparative smallness when on the vault of the skull, its painless and slow increase. Besides, the hypertrophies are not rarely symmetrical, and their general seat is in or near the superior maxillary bones; the tumors grow singly, and either on the vault of the skull or at the orbit.

In the treatment of these hard osseous tumors, excision is the only fit remedy for those on the vault of the skull. But it should not be undertaken unless it is certain that the tumor is increasing, or for some equally good reason; for the extreme hardness of the bone makes the operation difficult, and not a little dangerous. The tumors at the orbit, as a general rule, are not to be removed by excision or any similar operation; their hardness, deep connections, and frequent projection towards the brain, render such proceedings extremely hazardous. Occasional cures of such tumors by necrosis and spontaneous separation may justify, in some instances, the practice of exposing their most prominent part, and destroying it with some caustic, in the hope of killing the whole mass, so that it may exfoliate.

There is no probability of renewal of growth after the removal of an osseous tumor; and even when the base of attachment is left, it is not likely to grow up again. It is to be noted, however, that certain cancerous tumors of bones inclose a kind of osseous skeleton, and that a great part of an osteoid cancer may be heavy and compact bone. When these, like other cancers, recur, the secondary tumors, wherever seated, may contain bone; but the distinction between the cancerous and the simple osseous tumor is seldom difficult.

In a great majority of cases osseous tumors occur singly; but rare instances are occasionally seen in which patients have a large number on many bones. These are usually symmetrical and hereditary; and their growth, if not intrauterine, begins in earliest infancy. Indeed, they partake of the characters of monstrosities by excess, as much as of those of tumors.

Glandular tumors.—It is probable that growths of the nature of tumors may be formed in imitation of the structures of glands of all classes, whether lymphatic, vascular, or secretory. Most of them occur as tumors within the substance of the gland they imitate, but a few are formed outside it.

The distinction of lymphatic tumors from enlarged lymphatic glands may be drawn from the occurrence of tumors composed of the absorbent structures in situations not naturally occupied by healthy glands. In the disease named in England chronic enlargement of lymphatic glands, the number of the clustered tumors far exceeds that of the glands that could be recognized in healthy subjects. It did so too in the case from which Fig. 37 was drawn, and in which the lymphoid corpuscles constituting the disease inundated the textures in the manner of cancer.[1]

Among tumors resembling vascular glands, those of the thyroid are met with in both relations. Some appear as distinct and completely incapsuled masses embedded in the substance of enlarged thyroid glands or bronchoceles. They have their best parallel in the prostatic tumors inclosed in enlarged prostates; but their pathology is involved in that of bronchoceles, and they are not commonly counted as tumors. The name, however, cannot be refused to the similar masses which lie near the thyroid gland, but not in it, and which grow irrespective of its growth. They are too rare to justify many general statements concerning them. Their growth is, probably, most frequent in or near middle age; slow, painless, sometimes attaining a very large size. They resemble thyroid gland in both visible and microscopic characters; and, if any diagnosis could be made of one of them during life, it would be by the likeness of its "feel" and its proximity to the natural organ. But diagnosis would, probably, not come nearer than to the expectation of some innocent tumor, for which excision would usually be the proper and sufficient remedy.

[The author, both here and in other places, includes under the head of glandular tumors new growths which contain a structure similar to that of any of the glands, whether the secreting, lymphatic, or the so-called ductless glands. These several varieties have been separated in the later classifications into true adenoma and into lymphoma. The author also speaks of those growths, especially those on the skin or mucous membranes, in which the gland-structures of these parts become prominent as the result of a hyperplasia due to development of a neoplasm in the immediately adjacent parts. This classification is unfortunate, because the enlargement of the gland-structure is evidently merely an accident of such growths, the fibrous or some other form of tissue being the principal element of new pathological disturbance.

In respect to the adenomata, there has been great confusion of meaning in the past, and even at present all writers do not seem to have a clear conception of their value as morbid growths, and are not wholly agreed as to the various kinds of new growth to be included in this class. A newly formed glandular tissue is the essential basis of this growth; whether it takes place by the direct extension of a pre-existing gland, or whether there arises disconnectedly a formation of structure similar to gland-tissue, is certainly not as yet agreed upon. Accordingly as we set one or the other of these limitations to our definition of adenomatous growths, we shall be compelled to include or exclude various well recognized new formations, and, in some cases, tumors, which, excluded by the more limited definitions, from other circumstances connected with their growth or structure, we should be glad to include in this class.

These growths always represent true gland-tissue in all its details, and there are two varieties: 1st. Acinous adenoma; 2d. Tubular adenoma.

The first variety represents, as its name implies, a development of gland-structure similar to the acinous glands. It consists of epithelial cells, backed by a basement membrane, and arranged in a manner similar to that found in the acini and tubes of the gland. The connective-tissue stroma between the acini and tubes is usually very scanty. (See Fig. 55.) The lumen of the tubes and cavities of the acini may be entirely wanting, or only found in spots, and occluded with cellular elements or their degenerated products; they do not communicate with the excretory ducts of the gland.

Adenomata of this variety have been described as occurring in the liver, in the mammary gland, in the parotid, and in the sweat-glands. In the breast, true adenomata form but a small proportion of the neoplasms so frequently present in this gland; they have a distinct capsule, and never spread diffusely in the mammary tissue.

In other instances they have a genetic relation to the gland, and grows from it perhaps locally, perhaps diffusely, as buds from the parent stem, but the process takes its departure constantly from the epithelial part of the gland, and thus always

[1] Dr. J. Burdon Sanderson's Reports for the Privy Council on Tubercle, and to the Pathological Society on Lymphoma, 1869.

maintains an histological and also a physiological connection with the parent gland.

In other very rare instances the new-formed gland-tissue occurs at a distance from the gland. This heterotopy seems to be due to a fœtal anomaly, and is of congenital origin.

According to this view, the tumor many times exercises a physiological function in an entirely normal manner, but in the majority this is not the case; in both of these two instances the distinction between a glandular hypertrophy and a neoplasm is with difficulty to be made. When the new-formed gland-tissue does not communicate with a normal gland duct its products of secretion accumulate, and the growth tends, by further development, to become cystic. In consistence the growth is soft and elastic; or, if cystic, fluctuates; on section it presents a surface resembling a solid mass of gland-tissue of milky-white or rosaceous color, dotted with small orifices, or having larger or smaller cavities.

In the liver the new growth takes its rise directly from the acini of liver tissue, and from the anastomosing trabeculæ of the liver-cell net arise oval-shaped cylinders of cells, tubes, as it were, lined with cells which gradually replace the liver-substance, but in the same acinus both the normal tissue and new growth are seen alongside of one another. The growth extends peripherally, as well as by outshoots from cylindrical tubes. Later the growth is surrounded by a capsule, which excludes it from the surrounding liver-tissue, and its further development proceeds entirely by the formation of offshoots from the already existing tubes. When the growths attain a large size, the only change they present is a tendency to fatty degeneration and the formation of abscess. Metastatic formations do not occur.

Within the bounds of the wide limitations of adenomata many writers include growths derived from the sebaceous follicles. Of such growths certain tuberous enlargements of the nose and of the scrotum may be mentioned. Rarely this form of growth is a congenital anomaly, and allies itself to a dermoid growth. More commonly they are slow developments in adult or advanced life. The greatest part of the growth, however, is composed of a new formation of the sebaceous glands, with a marked hyperplasia of the interglandular connective tissue and of the vessels. So great is the increase of the connective tissue that one is reminded of elephantiasis. The cavities of the glands are invariably filled with their products of secretion in an inspissated condition, with desquamating epithelium and with oil or solid fat and cholesterine in crystals. The excretory ducts are not closed, at least in the fully-developed condition they are not usually so—but in proportion to the new size of gland the tube is wholly inadequate to its office, although in fact its opening on the skin-surface may be greater than normal. The great tendency of these growths is to ulceration of the surface at the summits of the prominences of the enlarged glands, the intervening portions of the skin usually remaining intact. The bottoms of the ulcers are filled with the contents of the glands, which can be crumbled out with pressure, but it is constantly renewed so long as the epithelial lining of the acinus remains.

There is also an adenoma of the sweat-glands, which formerly was confounded with carcinoma of these organs, but which is to be distinguished from the epitheliomatous growths which take their origin in them. They are more frequent on the face than at any other part; the axillary space, the skin over the sternum, and also the back furnish instances of them, and they exhibit a similar tendency to ulceration as those occurring in the sebaceous follicles. They always originate in the deeper parts of these glands, and therefore commonly have a deeper seat than the preceding.

The adenomatous growths found in connection with the mucous membranes belong to the *tubular* variety, in correspondence with the character of the glands which they imitate or from which they originate. They are most frequent in the nasal, uterine, and rectal mucous membrane, and take the form of polypi. The enlarged or new formed tubes are lined with huge cylindrical epithelial cells; their lumina are filled with clear mucus. The intertubular tissue is composed of fibres, loosely interwoven, and sometimes presenting appearances similar to myxomatous tissue.

In the ovary, Klebs and Waldeyer have pointed out that many of the cystic tumors are true adenomata, and similar growths occur in the corresponding organ in man, viz., the testicle. Virchow, Billroth, and others consider that many tumors of the thyroid glands are adenomata.]

Of the tumors resembling secreting glands the best-marked are the mammary, prostatic, labial, and parotid, named severally after the glands whose structure they imitate, and in which they are found. Leaving many facts concerning each of them to be related in the pathology of the several glands, it must suffice to mention here those characters which are common to them all. They all affect regular round or oval shapes, or are lobed as if compounded, or they may be flattened in adaptation to pressure. They are generally invested with distinct capsules of connective tissue, from which it is not difficult to enucleate them, and

through which they derive a sparing supply of blood-vessels. On section, they commonly appear lobed, or intersected with partitions of connective tissue, and are pale, grayish- or yellowish-white; in some specimens looking translucent and glistening, in others opaque; in nearly all acinous or glandular. To the touch, some, especially the whiter and more opaque, are firm, tenacious, and elastic; others, especially the yellow and more glistening, are softish, brittle, slippery, and succulent, with fluid like serum or synovia. Not rarely, cysts are embedded in the solid growth, and filled with serous or other fluids like those which are found in the barren cysts of the mammary gland itself. In the labial and parotid glandular tumors, portions of cartilage or bone may be mixed with the glandular structure. And, sometimes, chiefly in the mammary, the glandular tumors appear as if formed wholly or in part of clusters of small sessile or pendulous growths filling cysts or partitioned spaces; thus indicating their relation to the proliferous cysts described at p. 246, and suggesting that they originated in such cysts. The textures around the tumors are usually quite healthy, altered only by displacement. (See Fig. 36.)

It is not possible to state any general truths respecting the date or manner of origin, the number, the rate of growth, or other particulars of the life of glandular tumors. For a general rule of diagnosis it is true that any tumor in or near a gland, which presents the characters above described, and is regular, very circumscribed, smooth, mobile, surrounded by healthy structures, painless, and of slow growth, is very likely to be glandular; but the diversities in degrees of firmness, in pain, in size, in rate of growth, make the diagnosis, especially from cancer, sometimes very difficult. The mammary glandular tumors present many striking instances of this.

The glandular tumors, if we may regard the mammary as an example of the whole class, not only cease to grow more often than others do, but may be removed by absorption. This happens not rarely with small mammary glandular tumors, and their arrest of growth is frequent. Either event is most likely to occur when the natural function of the normal gland, after being suspended or retarded, comes to be duly exercised. Some of them disappear under treatment. When removal by operation is requisite, enucleation from within the capsule is the proper means, and is, with few exceptions, a final remedy. The exceptions are met with in cases in which very soft mammary glandular tumors are repeatedly recurrent. These will be referred to hereafter. It was mentioned at p. 252 that many of the softer kinds of polypi are composed, in great part, of glandular tissue. Some of them, indeed, including most of the so-called mucous polypi of the rectum, uterus, nose, and antrum, might properly be called glandular outgrowths; for they consist, mainly, of glandular structures similar to those of the mucous membrane from which they proceed, but arranged disorderly, and often dilated, saccular, or overgrown.

[The lymphomata are tumors which have their origin from lymphoid or adenoid tissue, similar to that of the lymphatic glands (see Fig. 57). These growths most commonly occur in situations in which lymphatic glands are present normally; lymphomatous growths occurring in other places were formerly regarded as of heterologous origin, until investigation showed that lymphatic or adenoid tissue is far more widely distributed in the parenchyma of the various organs than was previously known. Such growths, in fact nearly every lymphomatous growth, must now be looked upon as of homologous origin.

Two varieties of lymphomata may be described: first, those consisting of hyperplastic or hypertrophied glands; secondly, independent growths which, arising from glands or other lymphatic tissues, proceed more or less continuously to a great development; which frequently have as a cause or accompaniment a dyscrasic condition of the blood; and which, either from themselves or from the dyscrasia, terminate fatally. All grades of these growths are found within the limits of these two varieties, in respect to their cause, course, size, and malignancy. The causes may be common or specific. A lymphatic tumor may arise in connection with a simple injury or inflammation. Tubercle, scrofula, and syphilis are especially frequent causes of such glandular enlargements, and often demand surgical interference.

Lymphomata have been variously named by authors; by some they are spoken of as sarcomata, by others as lymphosarcomata, or again, as adenolymphomata or lymphadenomata. All of these tumors have as their type the normal structure of a lymphatic gland, and later the hyperplastic gland shows itself as a continuously growing tumor. Lymphomata have been sub-divided into classes according to their consistence, color, rapidity of growth, and their tendency to recur after removal. There is a form, which, attacking a collective group of glands, for example, the cervical, develops into a lobulated tumor of firm consistence and of slow growth —so slow as to appear nearly stationary. Each lobule of the mass corresponds to

one of the original normal glands, which become intimately matted together, and also with the nerves and vessels of the part, so that the complete removal of the growth is a matter of difficulty, if not impossible. This form of tumor, if not interfered with, exhibits, at least for a long period, a very low degree of malignancy. It is often a difficult matter to distinguish it from scrofulous disease; and it is sometimes impossible, unless subsequent to an operation, the growth returns with rapidity, accompanied by malignant phenomena. This enlargement of the lymphatics distinguishes itself also from scrofulous disease, which otherwise it closely resembles, by exhibiting no tendency to degenerate or to form abscesses. Another form or subdivision, characterized by a high degree of malignancy, is the softer growth, developing often with great rapidity and also successively in several groups of glands. The new formation is only at its commencement limited to the original glands; it soon bursts through their capsules, spreads into the surrounding tissue, and becomes a diffuse infiltration; even the venous trunks become invaded and penetrated, and the new growth takes place within their calibre, or is diffused as embolic masses through the blood current. It is difficult to decide whether the successive appearances of tumors in the various gland-groups are the result of a metastatic process, or are due to a general dyscrasia. The latter is probably the true explanation, since the secondary formations nearly always occur in glands, and not in other internal organs.]

Vascular or erectile tumors are such as have, for their chief and characteristic structure, minute bloodvessels, tortuous, saccular, or dilated, variously communicating, and, as it were, matted together in a mass which is embedded in the subcutaneous or some other tissue. Their most common seat is in or beneath the skin, where they are the so-called vascular nævi, but they may be found, though rarely, in muscles or intermuscular spaces, in the liver, in bones, or (it may be) in any other vascular structure. [No tissue of the body is exempt, excepting the non-vascularized cornea, cartilage, and vitreous body.] Those instances of the disease are alone reckoned among tumors which appear as masses or "lumps" of whatever size; those that are wide-spread, diffuse and superficial, such as the common cutaneous nævi (port-wine spots, spider-marks, and the like), are reckoned as separate examples of telangiectasis. The vascular growths here spoken of are also different from a tumor described by Dr. Moxon, and are composed of enlarged arteries, having massive tubes of newly-formed tissue in and aroundtheir walls.

[Telangiectasis, considered with reference to its histological details, is more than a simple dilatation of the capillaries —more than an aneurism of these vessels; there is an actual new formation of vessels of the skin. The process of development is conducted in the same manner as that seen in the tertiary vascular formation, by budding projections from the wall of the capillary, extending gradually into the connective tissue, and forming a loop which rejoins itself to the same capillary vessels at a more or less distant point; and thus a new blood stream is established.]

The vascular tumors are commonly divided into three kinds, named capillary, arterial, and venous. In the first, nearly the whole structure consists of the large, dilated, and convoluted capillaries, with which arteries and veins of not more than proportionate size are connected. In the second, the basis and chief mass of the structure are the same; but there is a very great excess of large tortuous arteries, proceeding to the mass, and even passing through it. The third, which is almost exclusively the nævus of childhood, has been found to be connected only with veins, the afferent, as well as the efferent vessels being venous: a great part of the mass has a cavernous, spongy structure, just like the erectile tissue of a penis.

The most frequent seats of the capillary vascular tumors are in the subcutaneous tissue of the scalp, face, and trunk. Some of them, seated entirely beneath the cutis, are covered with healthy skin; but in many more instances the cutis over the middle of the mass has the same disease of its vessels, and is crimson, very thin, and often granulated. The usual shape of such tumors is round or oval, more or less flattened (especially on the scalp); they are well circumscribed by connective tissue, which would probably form a perfect capsule but for the number of bloodvessels that pass through it to and from the contained vascular mass. The principal arteries usually enter the mass immediately beneath the skin; the veins leave it at all parts. On section after death or excision, the shrunken tumor, which during life was turgid with blood, has usually a brownish color, and is lobed, soft and tough. Its lobes are separated by connective tissue, and, it may be, fat, belonging to the natural structure beneath the skin and superficial fascia.

The minute vessels of such a growth may be best seen in microscopic sections made after boiling in acetic acid. They

present the most varied and complex convolutions and anastomoses; many of them are irregularly sacculated and varicose; and many that are much larger than ordinary capillaries have only the same simple structure as the smallest. The arteries leading to these capillaries are commonly more tortuous than those of healthy skin, but are not otherwise peculiar. The veins are ordinary, or only larger than for healthy skin.

The venous vascular tumors are not rare in the same seats as the capillary: but they are more often deeply seated; for instance (to speak only of such as may need surgical treatment), in or between muscles, in the orbit, or the tongue. In most of their characters they are like the capillary kind; but on section they look like fine network or sponge-work of shining bands and cords, and are often dark venous-colored in their meshes. Their collapse, after removal or section, is even more complete than that of the capillary tumors, so much so, indeed, that if in operations they chance to be cut into, they close in, empty themselves with a gush of venous blood, and almost disappear. Large veins pass from them, often tortuous and clustered, or like sinuses.

In the arterial kind of vascular tumor (the so-called aneurism by anastomosis), the peculiarity superadded to the general characters already described is, that numerous large arteries enter the mass at many points of its circumference, and before or directly after their entrance give off numerous branches which are variously tortuous and convoluted. Parts of the tumor, indeed, which may feel softly solid, may consist entirely of the convolutions of one artery.

[The cavernous tumor is frequently spoken of as a metamorphosis or degeneration of the vascular walls, which allows of the dilatation of the calibre of the vessel and the formation of acinous or sponge-like cavities. The microscopic details, however, show us that the process is one of new formation, in which cellular elements are deposited along the line of the vessels,—not merely the arterioles, but especially the capillaries. The new germinal tissue undergoes fibroid development and especially contraction, resulting in a dilatation of the vascular spaces, until finally there are produced larger or smaller cavities, filled with blood, and connected with the general circulation of the area in which the new growth takes place. The former tissue of the part composes the wall of the cavities, but it can no longer be recognized as the original tissue, and bears but little resemblance to a vascular wall.

The process may be looked upon as a fibroid growth in the walls of the capillaries; by some observers it is compared to an inflammatory change, and in some instances it appears to be related very closely to inflammation of the vascular tract. Cavernous tumors occur most frequently in adipose tissue, and have been observed to take place in lipomatous tumors. Billroth was the first to describe a cavernous degeneration of fibromata, and a similar degeneration occurs in other histioid tumors.]

To this general account of the structure of the vascular tumors, it must be added, that specimens are not rare which appear very different through degeneracy or other changes of the original structures. Serous and sanguineous cysts are rather frequent complications (see pp. 243, 245). Parts of the vascular structure may be consolidated either with blood-clots, or with phleboliths, or with closure of the vessels and a kind of scarring process. A good example of this is often seen at the centre of the cutaneous part of a capillary vascular tumor, which appears as a white, smooth, and scar-like patch, surrounded by a vascular ring. Similar scar-like portions are sometimes seen in the very substance of a tumor; and, occasionally, one finds nearly the whole mass of a tumor, which one may know by its history and some remaining characters to have been vascular, changed into a soft but tough and dry yellow-ochre or brown substance, like that of a suprarenal capsule. Moreover, though by far the greater part of these vascular tumors have their seat in circumscribed portions of normal structures, yet the enormous growth of bloodvessels in which they essentially consist may take place in those of a tumor, and convert part, or the whole of it, into a pulsating or erectile mass. By disease or injury, or during fever, they may perish or be acutely inflamed. A good result of such an accident is, that they may be consolidated; an evil one, that ulceration may ensue, exposing parts of their substance, and forming irritable and often bleeding sores, that rarely heal soundly.

The greater part of vascular tumors involving the skin appear at birth or in early infancy; and probably those that are deep-seated have an equally early origin, though they are longer overlooked. But such tumors may first appear in later life, small ones arising with singular frequency, and sometimes very extensive ones, in the neighborhood of cancers (p. 300). Their rate of growth is very uncertain, and often, as it were, capricious; sometimes proceeding very rapidly, sometimes even in the same tumor scarcely notable. Very commonly their increase is only proportionate to that of the rest of the body; and when full growth is attained, they also cease to grow. Not

rarely they are stationary, or shrink, even while the rest of the body is growing; and this is especially likely to happen with those that are white and scar-like where the skin is involved. Those which shrink may be sometimes trusted to disappear, but growth may ensue, or troublesome changes, in a tumor that has been even for many years stationary and quiet.

The diagnosis of a vascular tumor can scarcely be doubtful when the skin is involved; but in those that are deeper there may be great difficulty. The arterial, having pulsation, may generally be known by it; but for the capillary and venous, the chief signs to be looked to are, their circumscribed shape, softness, "puffy" feeling, compressibility almost to emptiness, slow swelling up when the pressure is removed, increasing size and tension during strong expirations, or when their venous trunks are compressed, or in depending postures, and sometimes their bluish tint seen through the skin. In this last character the nævus and congenital cyst are sometimes alike, while that of variation of size is common to nævi at the root of the nose and to meningeal protrusions through the frontal ethmoidal sutures. A mistake between the two diseases has proved fatal.

There are few, if any, tumors for which so various treatments are applicable as for these.

Excision is often supposed to be dangerous on account of hemorrhage; and it might be so in the case of a very large arterial vascular tumor. But there is no such danger in the capillary and venous forms: and if they be not cut into, and the knife be kept close to the investing capsule, they may be excised as safely, and almost as easily, as any other tumors of the same dimensions. The advantages of the plan are, that it is simple, painless (with chloroform), and complete, so as to need no repetition; the objections to it are, that if much skin have to be removed, it leaves unsightly scars, and that the possible consequences of cutting operations should often be avoided if the same end can be attained by safer means.

Some of these objections are avoided by the écraseur, and in certain of these tumors it may be very appropriately used.

Ligation has the advantage of safety from hemorrhage, and is appropriate to all nævi which are of a convenient shape, and are not too large to be treated all at once. The larger may be tied in two or four parts; and in situations where the removal of skin is objectionable, the ligature may be applied subcutaneously. It is, however, painful, and may be followed by tedious sloughing and suppuration, with other liabilities of open wounds.

Cauterization is a good means for many of the arterial tumors, especially when they are ulcerated, and for superficial nævi of irregular shapes. The actual cautery, or, of the potential, those that make the driest sloughs, such as the chloride of zinc, or the Vienna paste with much lime, should be used. These caustics may, also, be safely employed for the capillary and venous tumors; for those that are small and not deep, on the gums, for instance, or vulva, the nitric acid, or acid nitrate of mercury, or the needle cautery, is more convenient; while, for those that are large and deep-set, it is better to cut up and penetrate their very substance with probes armed with nitrate of silver.[1]

There are, however, few cases of the larger capillary or venous nævi, in which consolidation is not better than any use of caustics. It may be effected by injection of solutions of ammonia, or of tannic acid, into the substance or meshes of the tumor. The saturated solution of perchloride of iron introduced into the tumor, in drops, through numerous punctures with the perforated needle and screw-syringe, though commonly effectual, has occasionally proved suddenly fatal. In nævi of the face and neck, therefore, where this event has happened, this method of treatment should be abandoned. Setons may be used for a long narrow nævus, or for one of irregular shape. They are also suitable when the tumor is small enough for the inflammation caused by them to consolidate it in a moderate time; and their utility is increased if each thread be soaked in the solution of the perchloride. They should not be employed throughout the substance of large nævi at once, as they may set up a fatal suppuration.

Pressure, either with pads and elastic bands, or with firm bandages, or with the slack air-pad and truss-spring of Dr. Arnott, has been successfully used in some cases, even of the arterial tumors. It is most, or, indeed, almost only, applicable when the tumor lies over bone, or some other very firm base, on which pressure can be continuously made.

When a vascular tumor has been thoroughly removed or consolidated by any of the means above described, there is little or no probability of recurrence. If small portions have been left, they may increase, but, probably, as frequently they shrivel and slowly disappear; and generally, it may be remarked, that long after any of the methods of consolidation have been discontinued, curative changes

[1] The methods of employing caustics, ligatures, etc., for these and other purposes, will be described in the essay on Minor Surgery.

go on; so that a vascular tumor which may have appeared imperfectly cured, may, in a few months, be completely obliterated.

As an appendix to the foregoing account of tumors, it may be well to refer to some, or to certain diseases resembling tumors, that present prominent characters so peculiar as to have suggested names by which they are, with some practical advantage, often spoken of.

Recurrent tumors.—In the preceding pages it is stated of each kind of tumor that, after the complete removal of one, no similar growth is likely to occur on the same part. This is the general rule for the whole class of innocent tumors. There are, however, examples of tumors which, in respect of structure, resemble those that are usually innocent, and yet constantly recur or renew their growth after even repeated, and apparently complete, removals. The character is so important, whether in a pathological or in a merely practical view, as to justify the grouping of these tumors, under a distinctive name, apart from those with which, according to their structure, they should be arranged.

The greater part of the recurrent tumors hitherto observed have, in structure, most nearly resembled the fibro-cellular or fibrous; and hence the name of "recurring fibroid" by which Mr. Paget first described them. But some are cartilaginous; some glandular; some in the form of proliferous glandular cysts; and it is probable that the character of recurrence may be found in certain rare instances of tumors of any other structure. This, however, belongs to all yet observed, namely, that their structures are imperfectly developed; resembling the embryonic, or rudimental, rather than the perfect, states of the several natural tissues. (See Figs. 28, 29.) Thus, the recurrent fibroid are composed, chiefly or entirely, of elongated, caudate, oat-shaped or awn-shaped nucleated cells, resembling the so-called "fibro-plastic" cells, which are a chief constituent of granulations, and other examples of developing connective tissue. And this rule of persistent or arrested embryonic structure in the recurrent tumors is so general that, in practice, it is prudent to speak very doubtfully about the future of any case in which a tumor that has been removed presents embryonic structures.

The general appearance of recurrent tumors is, in their first growth, often not distinguishable from that of tumors of the same structure that are not likely to recur; they may look like ordinary fibro-cellular, fibrous, or other tumors. More often, however, they differ from these ordinary tumors in that they are softer, more succulent or glutinous, glistening or translucent, brittle or easily torn, with a kind of fibrous grain. Commonly, all these peculiarities become more marked in the successive recurrences of the tumor; and the later growths are, generally, like masses of yellow or ruddy soft gelatine, with bloodvessels. The later are, also, usually much more rapid in their progress than the earlier growths, softer, less well defined, penetrating further and more vaguely among the interstices of adjacent parts, more quickly protruding through the skin or scars over them, more friable and readily bleeding.

The group of recurrent tumors corresponds very closely with those which Virchow designates SARCOMA. By this term he intends not a mere fleshy look, though the uniform aspect of such tumors on section is in marked contrast with the obviously structural arrangement of their innocent relatives, but that the tumors in question have a specific microscopic construction. With Mr. Paget, he regards their main distinction as that just described in their cells, and he observes that the smaller-celled tumors are the more prone to spread in the body and to recur after operations. The nuclei and nucleoli are usually large, and, in consequence of the fragility of the cells, may be found free.

Cells of this kind may constitute a tumor alone and from the first, or may begin to form in a part of one which was originally of a simpler kind. Thus, a mucous or a cartilaginous tumor, a myeloid or a bony growth, a glioma or a fibrous tumor, may have mingled with it cells of the sarcoma, and a compound tumor may result. The tendency of the latter cells being to supersede the earlier ones, the character of the sarcoma comes to exclude more or less completely that of the original growth, as the tumor advances in size or in age, or as recurrences after operation are multiplied. A difference of sarcoma from cancer is sometimes as little traceable in its structure as in its life, and the resemblances between the two in their clinical progress, in local recurrences and dissemination in the body, correspond with the likeness in their anatomy. As, however, sarcoma may exist with an innocent growth, so may it concur in the same tumor with cancer. In such cases, Virchow considers the distinction between the two to be the constant relation of the sarcomatous cell to intercellular substance, whilst the cells of cancer may grow in clusters separated by fibres, but not mingled with them.

The combination of characters like and unlike those of cancers suggests that the

recurrent tumors may be diseases intermediate or transitional between the innocent and malignant. And the suggestion is strengthened by the comparative frequency of their occurrence in the descendants or near relatives of those who are or have been cancerous. It is as if their growth were due to some diathesis through which the cancerous, in some instances, fades away into health, or is, in some, gradually developed.

[The term recurrent tumors, as first used by Paget, and with the meaning he gave to it, was at that time of great advantage to surgical practice, and its establishment reflects great credit on this very distinguished man, since thereby attention was fixed on a group of tumors which previously were little known or were confounded with cancerous growths. This term is now no longer made use of by other observers, and the growths which were placed in this group by Paget are now, along with other forms, called sarcomata.

Virchow revived the name sarcoma, and since then it has been applied to those new formations characterized by a predominance of embryonic tissue. Probably no other class of tumors retain so much uncertainty concerning their anatomical, as well as their clinical, aspects. Billroth defines a sarcoma as a tumor consisting of tissue which belongs to the developmental series of connective tissues, and which does not, as a rule, go on to the formation of a finished type of tissue, but tends rather to peculiar degenerations of the developmental forms. It must be remembered in connection with this definition that, from an embryological point of view, all tissues of the organism which are not epithelial belong to the connective-tissue series, and since the point of departure of the sarcoma is always from the connective tissue, the tissue of origin influences the histological characters of the new growth; thus sarcomata from the fascia and the periosteum have spindle cells, and in the latter there is a tendency to bone formation; those of the skin and choroid have their cells pigmented. So likewise other tissues of the connective-tissue series tend to reproduce their structural peculiarities in the new growth.

The classification of sarcomata might be made on the basis of the tissue or organ from which they originate; indeed, attempts in this direction have been made—since exactly the same histological structure of these growths can only be reproduced at exactly the same point of the body. But such attempts could only result in a great multiplicity of terms without increasing the definiteness of our conceptions of their physiological pathology. We can classify sarcomata according to two principles, a histological and a clinical.

Histological classification.—Three principal varieties of sarcoma are usually described, under which heads all these tumors can be brought, but to which may be added others having certain peculiarities or modifications from the addition of other types of tissues. Thus we have the round-celled, the spindle-celled, and the giant-celled or myeloid sarcomata, and although these varieties are very clear and definite in their histological characteristics, yet they are not well distinguished by their clinical history. Besides, the three varieties of cells are frequently found in conjunction in the same tumor; usually one form predominates, and from this the tumor is classified. Any attempt, however, to classify tumors solely according to the cellular elements which constitute their mass, must end in disappointment, and would be a reversion to the old methods of histological study. The method by which, from merely scraping the cut surface of a new growth and finding in it irregular shaped cells, the tumor was pronounced a cancer, has passed away. It is the arrangement and mode of development which constitute the characteristic features of the tumor, and determine its classification. The round-celled tissue (See Fig. 52), corresponds most closely to the earlier stages of the inflammatory process, the cells of this variety of sarcoma resembling lymph-corpuscles, white blood-cells, or the granulation cells of connective tissue. The cells, however, differ greatly in size, and this feature, as well as others which they possess, often varies according to the tissue or organ in which the new growth originates. They are extremely delicate bodies, having large nuclei; in fact the cell body or protoplasm may be so poorly developed as to give the appearance of free nuclei. The inter-cellular material varies likewise, in each subdivision, with the tissue of the seat of origin, if indeed in the strict sense of the word there exists any inter-cellular or basis substance; for most generally, like the inflammatory tissue which it has as a model, the tissue intervening between new cell growth is the normal tissue of the part distorted or partially destroyed. We may see occupying this position muscular fibres, adipose cells, or more commonly fibrous or connective tissue. The vessels are in great degree those of the normal tissue, although new capillaries of large size and very thin-walled soon appear; so that we may have, therefore, side by side with the original vessels, others wider and thicker-walled, and new capillary loops. The physical characters of the growth are that of a yellowish or reddish mass, uniform unless subdivided by bands or areas of the normal tissue variously changed, soft and elastic, and nearly devoid of fluid.

The new growth occurs most frequently in the connective tissue, the periosteum, and the nerve sheaths, and the membranes of the nervous centres; likewise on the skin, mucous and serous membranes, and in the connective substance of glands. This subdivision of the round-celled growths differs in its structure from granulation tissue, as it were, quantitatively, merely in that it develops into a tumor. It develops into, and is closely allied to, the spindle-celled growth. Its malignancy is of low grade, and herein it differs from other varieties of round-celled sarcomata.

Another variety of the round-celled sarcoma, called by Rindfleisch lymphadenoid sarcoma, is of softer consistence than the preceding variety, and gives, on scraping its cut surface, more fluid, in which abundant cellular elements are present. The cells are nearly uniform in size, with large nuclei and small nucleoli. The characteristic feature of this subdivision is that the cells are inclosed in a delicate mesh, or, rather, have a fine intercellular network, to which, however, the cells seem to have but slight adhesion. The capillaries or blood tracks seem to run nearly naked through the growth; so delicate are their walls, that this structure can with difficulty be distinguished. The new growth bears a certain similarity to lymphatic tissue, and is characterized clinically by a high degree of malignancy. In another form of this variety of sarcoma, the round cells present themselves of very large size, approaching that of epithelial cells, but otherwise their structural peculiarities are the same; with the increase in the size of the cells, a corresponding lessening of the consistence of the growth occurs.

Another variety of the round-celled growths is that named by Billroth *alveolar sarcoma;* and so closely does it resemble carcinoma, that it is spoken of as *sarcoma carcinomatodes* (see Fig. 54). It is a rare form of growth, and its anatomical distinction becomes often a matter of great difficulty. The cells are the largest of all the round-celled tumors, approaching that of cartilage cells (which to my eye they most resemble in appearance) or of largest sized pavement epithelial cells, but unlike them, not flat; their nuclei, relatively to the cells, are smaller than in the previous varieties, and have bright nucleoli. The characteristic feature is the grouping of the cells in alveoli, and having between them as a basis substance an intercellular fibrillated or homogeneous material. The cells are intimately united to the alveolar fibres, and this peculiarity is one of their distinguishing histological characters from epithelial growths (carcinoma). Another variety, exceeding even the great malignancy of this form of growth, is the pigmented sarcoma, the so-called pigmentary cancer.

I fear that this presentation of the varieties of round-celled sarcomata cannot fail to be unsatisfactory as a picture of a group of tumors; as a definite histological scheme, these forms are well marked, and very clearly to be made out by those familiar with examination of morbid growths; but it must strike every one, not content in teratological studies merely with a classification of neoplasms according to the variety of the cells discovered, that the difference in these varieties is one of degree or quantity, rather than something more essential and sufficient in itself to lead to a distinction of these forms into separate classes of tumors.

The *spindle-celled sarcomata* correspond to the fibro-plastic tumor of Lebert and the recurrent fibroid of Paget. They are found to exhibit two principal forms, viz., the small-celled and the large-celled.

The *small-celled spindle-celled* growths occupy a position among sarcomata similar to that which cicatricial tissue, developing into fibres, does among inflammatory new formations or interstitial inflammation. In this comparison the round-celled growths represent embryonal formative tissue, the spindle-celled sarcomata correspond to the transition of the embryonal tissue into spindle-cell tissue, which is the last stage in the process of transformation of the inflammatory exudation into organized matter previous to its becoming a fibrous cicatrix. The fibres which are so frequently seen in this variety of sarcomata must be regarded as the cicatricial stage of development. By some authors who include fibromata in the class of sarcomatous growths, the initial stage of all fibromata is represented by tissue similar to that of small round-cell sarcomata, which subsequently passes through a spindle-celled stage before it becomes a nearly purely fibrous structure.

Small-celled spindle-celled growths are constituted of cells massed together like grains of oats, and having a very similar shape, with oval or elongated nuclei, with or without a nucleolus. According to the consistence of these tumors the cells are in contact or slightly separated. The intercellular material, which always exists, even if only in slight amount, is of the nature of a cementing substance. The cells are arranged in bundles or in tracts, and appear in a thin section, cut in various directions to their long axis, either longitudinally, transversely, or at various angles of obliquity. The bundles appear to have no characteristic relations to each other, in respect to the direction which they pursue, neither do they maintain a constant bearing in reference to the original

tissue of the point or points of origin, or to the bloodvessel supply.

These growths occur in the fibrous membranes, especially the periosteum, the nervous envelopes, and, judged by their microscopic appearances, the vascular walls; in fact no place can be excluded as their point of departure which possesses a connective tissue. Their physical characters are those of a firm, tough, fibrous growth, usually of a grayish color. On section, their tissue appears variously arranged according to the direction of cellular bands or tracts; sometimes they are brittle or friable, breaking under pressure in the direction of the cellular bands.

In respect to malignancy, these growths exhibit this character in but low degree, and they rarely attain a large size; but the tendency to recurrence is often strongly marked. This tendency may be described as their prominent feature, to which emphasis has been given in the name proposed by Paget, recurrent fibroid. The recurrence takes place in the cicatrix, or near it, often with great rapidity after their removal. Gross records a case undergoing twenty-three operations within four years, the number of tumors removed being fifty-two, varying in size from a small almond to a pullet's egg.

The *large-celled spindle-celled* variety is characterized by the development of often enormously elongated cells, ending in tapering processes; sometimes, according to Virchow, three or more processes occur, but this is exceptional, two being the rule. The cell-body is broad at the part where the nucleus, or sometimes nuclei, are placed, its protoplasm is finely granular around the nucleus, as is likewise often the case in the small-celled variety, and from this part the long cells taper, more rapidly than in the shorter ones, towards the almost filiform processes. The nuclei are oval or round, with a bright-point nucleolus. Both this variety, as well as the small-celled, is often combined or interspersed with round cells (which must not be mistaken for spindle cells, cut transversely through their nuclei), filling up the interspaces between the tail-processes, or even occasional clefts between the bodies of the cells. Whilst tumors constructed of these large cells have been erected into a separate variety, and have been considered by some as quite a different thing, it is not probable that they differ from the small-celled growths in a greater degree than the variations presented by spindle-cell tissue of inflammatory new formation. In this tissue we may meet occasionally with colossal spindle cells, exceeding in size those usually found by as much as those of the large-celled sarcoma surpass the small ordinary round-celled tumor.

The third principal variety of the sarcomata, the *giant-celled* sarcoma, is characterized by the presence of very large masses of protoplasm. (See Fig. 53.) These giant cells, or myeloid cells, occur in connection with the two previous varieties of cells of sarcomatous origin, viz., the round cell and the spindle cell; then, too, the myeloid cell may constitute the principal mass of the tumor, the cells having interposed between them fibrous bands, indifferent tissue, or the remains of the bone from which by preference they are wont to grow. These myeloid cells, as their name implies, are like one of the constituents of the marrow of normal bone, and unquestionably their presence indicates a structural homology in many of the tumors in which they are found; whether they have this significance in all cases depends on the value and meaning which we give to the giant cells. Recently it has been shown that these masses of protoplasm, containing many nuclei, occur in various pathological formations, besides the normal occurrence of them in the medullary tissue of bone, as well as in this variety of tumor.

In miliary tubercle the giant cell has been shown to exist, and was once claimed as pathognomonic of this growth; in the inflammatory (catarrhal) exudation into the lung alveoli it is likewise to be found, as well as in other pathological products. Under these circumstances of occurrence the giant cell means increase of cell protoplasm and nuclei division without the usual accompanying result,—cell division. Are we to give the myeloid cell of the sarcomatous tumors, for example, those of bone, the same meaning, or is its histogenetic relation to be traced directly to the somewhat similar masses of protoplasms occurring normally in bone? If the latter theory is accepted, a different classification, or at least a different meaning and value must be given to those sarcomatous tumors occurring in muscles or in the mammary gland, in which giant cells are found, from what is at present assigned, or else the subject of myeloid sarcomata, in fact of sarcomatous growths in general, stands in need of careful revision.

With many pathologists, the myeloid sarcoma is a central sarcoma of the bone; *i. e.*, a growth from the medulla or the osteo-blastic layer lining the medullary canals. As a rule the central growths are myeloid sarcomata; the tissues between the myeloplaques, the stroma, as it were, is composed of varieties of sarcomatous tissue, it may be fibrous, or round-celled, or, as is most common, spindle-celled; a remnant of osseous tissue may exist giving the tumor an ossific character other than that derived from

the ossification, to be spoken of later, which is so common a feature of these tumors.

The physical characters of myeloid sarcomata are those of an ovoid or spherical tumor, well-defined and generally invested with a capsule, and this capsule is frequently composed at least in part of plates of the original bone expanded and thinned by the outward progress of the tumor; unquestionably this bone also is a product of new formation (if such is not always the case), from the periosteum which spreads itself over the growth. These tumors are generally firm, though in this respect they vary considerably from the character of tissue on the one hand, and on the other from degenerative changes to which they are subject. On section, the cut surfaces have a smooth, compact, shining succulent appearance; the color varies very greatly, in the small and younger growth being grayish or yellowish-white, while in the large growths it is generally blotched or streaked with various shades of red or yellow, the latter looking often like masses of gelatine. In respect to ossification of these tumors, it is doubtful whether true bone formation occurs, except as above spoken of by periosteal development over the surface of the growth, and this process can hardly be considered as an essential characteristic. The masses or spiculæ found in the interior of myeloid growths we must look upon as due to calcification of the intercellular substance rather than to true bone formation.

This variety of growth is of rapid development, and quickly deforms and destroys the affected bone. It is sure to re-develop unless the part, for example, the whole bone, is removed, but if this is done recurrence rarely takes place, certainly much less frequently than in many other forms of sarcoma, although metastatic formations sometimes appear in the internal organs.]

The rules for the treatment of recurrent tumors are the same as for those which their structures most nearly resemble. It is not more important in the cancers than in these to operate early, and in their excision it is necessary to cut wide of them, because of the difficulty of enucleating them, and the liability to leave fragments of them. No limit of number can be stated beyond which it would be wrong to remove these tumors as often as they recur; for there will always be some probability that recurrence will not again ensue. Mr. Paget has known cases in which recurrence ceased, for at least seven years, after a fourth and a sixth operation; and after every operation the patient may expect to enjoy a period of comfort. Dr. Esmarch of Kiel—an authority not likely to err—told Mr. Paget that he had seen cases of recurrent fibroid tumor cured, and not again returning, in patients who took large doses of iodide of potassium for several weeks. Generally, the prognosis of recurrent tumors must be unfavorable, unless Dr. Esmarch's plan prove often curative. The ordinary course is, that the tumors constantly recurring grow more rapidly; leave shorter intervals of health; protrude sooner; bleed and discharge ichor more freely, and affect deeper and deeper structures, till excision becomes too dangerous, and the patient dies exhausted. In some cases, however, as already stated, recurrence, after many times, ceases, and the patient may then regain perfect health.

Irritable or neuralgic tumors present, with whatever other characters, an altogether disproportionate intensity of pain; pain such as can be compared only with that of severe neuralgia, like which, too, it is at present quite inexplicable. The tumors with this peculiarity are most frequently subcutaneous and fibrous, or fibro-cellular; and to these the name of painful subcutaneous tubercle is often given. But the pain depends on neither their locality nor their structure: for, in the same situation, the writer has found fibro-cartilaginous and fatty tumors similarly painful; and the same kind of pain is observed in the irritable mammary glandular tumors. Neither is the painfulness of these tumors evidently due to any peculiar connection with nerve-fibres; for many of them have no manifest connection with nerves; and tumors in nerves, or involving them, are very rarely painful in the same manner or degree as these.

The most frequent seats of tumors thus painful are the limbs and breasts. They are much more common in women than in men; and are very rare in both early life and old age. Their increase is usually very slow; and it is remarkable that they seldom, if ever, grow much beyond half an inch in diameter. They are not prone to inflame, or ulcerate, or undergo any degeneration.

The diagnosis of these tumors is established by their pain. It is not usually constant, or is not always nearly equal in severity, but is, rather, paroxysmal, and is provoked to its greatest intensity by injury. It is often described as darting or flashing from the tumor to adjacent parts; often, it increases continually for an hour or more, and then slowly subsides; and, while it continues, the tumor is generally excessively sensitive to the touch, and often swells. In some patients the pain is attended with spasms of adjacent muscles, or even with general

epileptiform convulsions, or with syncope.

Excision is the proper remedy for neuralgic tumors. Their pain can rarely be mitigated by any local means, unless, in some cases, by circular pressure round them, as with a ring laid on the surrounding skin and deeply impressed. After excision, the pain is not likely to return in the scar; and if the excision be complete, no recurrence of the growth is to be expected. Cancerous growths, indeed, even in the skin, appear not liable to be thus neuralgic.

Pulsating tumors.—The chief interest of these lies in the necessity of distinguishing them from aneurisms and from one another. Any tumor may appear to pulsate when it lies within the range of the pulsations of an adjacent artery; but, in this case, it will not pulsate equally in all directions, or as with equal expansion, but chiefly where the artery is nearest; its pulsations, also, will cease, or be diminished by moving it from the artery; its bulk will not quickly vary, according as the blood-stream through the adjacent artery is allowed or checked by pressure. Pulsation not thus communicated, but due to the condition of the tumor's own blood-vessels, is natural to arterial vascular tumors. It may be found also in medullary cancers and myeloid tumors, which appear to be the only kinds liable to this condition, and that only when bound to, or partly contained in a bone. Free tumors, though vascular as a spleen, do not beat.

The diagnosis between pulsating tumors and aneurisms is dealt with in the essay on ANEURISM. That between the several kinds of pulsating tumors must depend on the other characters which they severally present.

Floating tumors.—Thus certain "lumps" are named, which are not rarely felt in the abdomen. They are most frequent on its right side, and in women; and most frequently they feel about as large, and of nearly the same shape as a kidney. They are usually smooth, moderately firm and elastic, and are singularly movable in the abdomen, so that they can be pressed upwards under the ribs, or downwards nearly to the pelvis, or, again, to the loin, or across the middle line; and as one examines them, they seem to slip away under the fingers, and have to be again searched for. The patient is conscious of the movements of the tumor, and sometimes describes them as a "swagging," and feels much discomfort from them, and generally ascribes to the lump some dyspeptic troubles.

It is usually impossible to say what a "floating tumor" is. Some suppose them to be all movable kidneys, *i. e.*, kidneys attached by loose tissue to the loin, so that they can be freely moved. But if they were so, such kidneys ought to be not unfrequently seen in autopsies; for floating tumors are not rare. Doubtless, in some cases, the apparent tumor has been a kidney; in some it has been a loosely attached ovarian cyst or tumor; sometimes feces, impacted in the colon, have long felt like such a tumor; but in many instances the case remains to the last unexplained, a constant annoyance to the patient, though probably without any direct influence on the health.

Phantom tumors.—Partial contractions of muscles may produce, by the swelling and firmness of the fibres, an imitation of a tumor; and when the contraction subsides, the tumor disappears, phantom-like. The abdominal muscles of hysterical women are most often thus affected; sometimes with intentional fraud. The imitation of a tumor may be so close as to require great tact for its detection, or else chloroform [or ether], which, by relaxing the muscles, dissipates the swelling. The same effect may be produced by prolonged kneading of the muscle with the hands. Occasionally these apparent tumors move. A child was lately brought to the writer with what was described as a "shifting tumor" in the neck. Some of the fibres of the right trapezius muscle, contracting, rose-up tumor-like; and as they relaxed, and similar contractions affected, successively, other bundles more and more distant from them, the "tumor" seemed to move from one part of the muscle to another.

CANCER.

By C. H. Moore, Esq.

Revised by Morris Longstreth, M.D.

Besides the characters already indicated which are common to or distinctive of innocent and malignant growths, there are a few which eminently belong to the Cancers, and which may be conveniently added in this place.

Cancer is unlike innocent tumors, in its infiltration amongst the natural tissues. The diffuse growth of the cancer and the concentration of the tumor are equally plain to the naked eye, and in respect of structures only discernible by the microscope.

Cancer exhibits a destructive hostility to the previous or the adjoining natural structures. It is usual with innocent tumors to respect those structures, merely displacing or compressing them; sometimes even leading to their hypertrophy. Before the cancers, however, indigenous parts disappear, being supplanted by, perhaps appropriated to, the new tumor. Some portions of the old organ may yet escape the common destruction, and be worked into the structure of the cancer.

The material composing cancer is short-lived. Remaining in its early condition of development, it is never elaborated into an enduring structure, and has less stability than normal tissue, than the tumors, or even than adhesions and scars, and is prone to ulcerate, wither, or slough. The total mass of cancer produced, consequently, far exceeds that existing at any one time. There is also a gradual deterioration of it, that which is last produced deviating more than the earlier growth from the natural elements. In advanced cancers, the transitory cell element predominates, and with it a great succulence of the tumor, a more rapid growth, a quicker decay, a readier dispersion in the body.

The microscopic structure of tumors offers the most ready means of distinguishing their innocent or malignant character. There is, indeed, no single element of a cancer which may not also be found in some tumor called innocent. Fibre, cell, nucleus, nucleolus, molecule, liquid—all exist elsewhere, as well as in cancer. But neither in tumors of innocent character, nor in natural tissue, do these elements combine in such variety as is common in a single cancer.

The prominent surgical character of cancer is recurrence. Though cut out, or destroyed by internal change, it returns. And if it do not return in the part, it nevertheless resumes its growth, as if it had not been cut out, in other and distant organs of the body. Yet, whilst this is given as a characteristic of cancer, in contrast with the habits of innocent tumors, neither the statement nor its converse is of universal application. There are innocent growths which never are finally extirpated, by repeated operations; there are cancers which never reappear.

With rare exceptions, such as have just been mentioned, cancer is fatal. Sooner or later, if life be not cut short by other intercurrent disease or by some accidental consequence of the local tumor, cancer naturally issues in death.

Varieties of cancer.—The very various forms in which cancer presents itself to the notice of the surgeon admit of the following arrangement:—

Scirrhous.
Medullary.
Melanotic.
Epithelial.
Osteoid.

It is not uncommon to regard the diseases termed Colloid and Villous as varieties of cancer, but their appearance in surgical cases is rarely such as to favor that classification. Their distinctive characters will be made apparent after a previous description of the true cancers. Other forms of the disease are also noted by pathologists, as cysto-carcinoma, dendritic, and reticulate cancer, and fungus hæmatodes; but their nature and clinical history are not substantially different from those above enumerated. Rokitansky regards the product of enteric fever in the mucous membrane and glands of the intestines, and in various glands, as of the nature of medullary cancer.

Scirrhus.—Scirrhus is the most frequent form of cancer in this country. The chief site of its primary growth is the female breast; but it is also met with in the tonsils and large intestine, especially the rectum, in the eye, testis, and uterus, the

skin, bones, and parotid gland. Secondary scirrhus, though it may occur in almost any structure, frequents especially the lymphatic glands, liver, and bones: in the eye and testis it is unknown. With the exception of the osteoid, scirrhus is the densest example of cancerous structure. In certain organs, and when of rather large size, it is quite distinguishable by its stony hardness; but this character is far from being universal or pathognomonic, even in the breast.

1. The material of scirrhus most commonly concentrates in a mass, and in early stages of the disease often possesses every character of a tumor but that of swelling. For, as it grows, it exhibits the singular property of drawing into it adjoining structures, and including, or, as it were, compressing them with its own substance in a less space than that which, without any cancerous infiltration, they previously occupied. It is, therefore, only a considerable growth of the disease, œdema, or emaciation of the organ it occupies, which occasions an appearance of enlargement. The firm hold which scirrhus thus takes on all adjoining movable structures gives it a character which is not possessed in an equal degree by other tumors. These move amongst the tissues; that moves only with them. In certain situations it can indeed be moved, but only because of the looseness of the surrounding tissues, not because it is unconnected with them. The adhesion of scirrhus to adjoining structures is nowhere better shown than in the rectum, which it tightly constricts, or the breast, where the early shortening in of certain subcutaneous fibres towards the tumor produces a dimpling or pitting of the skin: the same change in the milk-ducts retracts the nipple, and in the submammary tissues, restricts the sliding of the breast over the pectoral muscle. Acute suppurations over a fascia sometimes look like cancer, on account of their producing a similar pitting of the skin, but are distinguishable from it by their uniform firmness, the tension of the intervening convex portions of the integument, and their redness, tenderness, and duration. Until a cancerous tumor has involved the whole of the skin which lies over it, the adhesion is even more marked, because of the looseness and plumpness of intervening portions of the skin which are not so fixed by subcutaneous fibres to the tumor. It hardly, perhaps, needs to be stated that scirrhus shows this contractile power only in soft and loose structures; there is no contraction when it is formed in the interior of a bone.

Scirrhus grows less by centric than by superficial increase. This is clear from its encroachment upon adjoining structures. Its surface is consequently unequal, and variously nodulated and fissured; some tissues being promptly embodied in the advancing tumor, others long resisting it. Moreover, it does not grow equally in all directions. It increases most on the side of the chief arterial supply, and in that towards which by lymphatics and veins its constituent fluids most easily filter. Hence growing mammary cancers spread most upwards, and cancers of the cheek towards the neck. Growth is further interfered with in another way. One part may be enlarging, while another is stationary, sloughing, or ulcerating. Thus, while one part is progressively softening and sloughing away, new morbid material may continue to be deposited in the tissue beneath and around it. In this manner a whole organ, a bone, or the wall of the chest, is sometimes perforated, and beneath the gap remains a cancerous basis of the ulcer still. The enlargement of a primary scirrhus is not always traceable to its own growth alone. In apparently healthy adjoining structures smaller tumors may form, and, as they also grow, may meet and unite with the primary tumor. This mode of incorporation is frequently seen when the subordinate tumors are in the skin, but it is met with also in deeper structures. In the vicinity of mammary cancers, for which the whole breast has been removed, many such tumors may be dissected out, scarcely any of which were large enough to have been detected before the operation.

The mere enlargement of a scirrhous tumor is not always a proof of its increase as a cancer; nor, except in rare instances, may its diminution in size be regarded as a cessation of specific cancerous growth. Many patients apply for advice, in whom a scirrhus can be indistinctly felt amongst tumid and tender tissues; but rest in bed for a few days, and suitable applications, diminish both. Neither the increase nor the reduction of the size in such a case is cancerous; they are due to the accession and the removal of inflammatory œdema. In like manner, a still more marked and definite swelling of the tumor itself may be occasioned by an attack of suppurative inflammation, and upon its subsidence and the evacuation of the matter the cancer may be found but little larger than before. Nor can the partial swelling which attends the softening of a portion of the tumor be regarded as an increase of the proper cancer. Partly with disintegration of existing cancer-material, partly with the addition of liquid from the blood, or pus, or of extravasated blood itself, a softening of a portion of the tumor takes place. Such softening produces a limited enlargement of the tumor; and if it occur near the surface, the skin over it becomes thin and red, and at length bursts. The soft-

ened matters then escape, and leave in their place an open excavation or ulcer of the cancer. It is probable that some of the acute suppurations beneath and in the vicinity of a cancerous tumor owe their origin to the escape of such softened débris of cancer-material, since they not unfrequently arise without an adequate assignable cause, and it is certain that softening is not limited to the cutaneous surface of the tumor.

At whatever rate scirrhous cancer may at times grow, its increase is subject to considerable variations. Sometimes it remains unaltered for weeks or years, and then renews its vigor and again enlarges. A scirrhus in the parotid region, after being stationary for eight years, grew rapidly on one side only, and doubled in size in two months. Bell, in his Thoughts on Cancer, 1786, pp. 94–96, describes the cases of two women who came to him with ordinary occult scirrhus of the breast, in whom rapid and extensive cancerous infiltration of a great part of the surface of the trunk took place, and destroyed life in a very painful way. The one died in a fortnight, the other in three weeks after he had seen them. In one, aged forty-six, the disease had lasted a year and a half, was perfectly movable and circumscribed, and unattended with axillary disease. A fortnight afterwards she was in bed, supported, breathing with quick and difficult respirations, with her pulse rapid and feeble, and in great pain. The breast was greatly enlarged, firmly adherent, but not ulcerated. The muscles of the abdomen, neck, and arm on that side were all enlarged, hard, and so contracted that her head and thigh were bent together. The other patient's case was a similar one, and her age thirty-nine. Such an outbreak of cancer-growth, though much less severe, occurred in the practice of my colleague, Mr. Shaw. A lady underwent the operation for extirpating a cancer of the breast, and remained well for three years afterwards. A trifling ulceration of the scar then took place; it was never larger than a shilling-piece, but it continued open for eight years. Exuberant cancer-growth then somewhat suddenly recommenced in the site of the operation and in the neck, and rapidly carried off the patient. Another patient of Mr. Shaw's was for many years in one of the cancer-wards of the Middlesex Hospital. Her breast had once been removed in another hospital with caustic, but the disease returned, and advanced with a very slow and scanty deposition of cancerous material. In about the twentieth year of the disease the character of the growing altered; large masses of cancer formed with rapidity on the side of the thorax, and she speedily died.

Had the surgeon operated in Bell's cases, the frightful outburst of cancer-growth would have been attributed to his interference; but, in fact, these changes occur upon no manifest condition, and without the employment of medical means, which are sometimes vaunted as exercising control over other examples of the disease.

The most remarkable occurrence is unhappily that which is most rarely seen, viz., a complete cessation of growth, and a slow diminution or withering of the primary cancer. Such cases as the following illustrate this occurrence in scirrhus; it will be noticed again in the section devoted to epithelial cancer.

A female patient had a scirrhous tumor in the right breast, with an enlargement of cancerous nature in the right axillary glands. A small tumor likewise existed beneath the nipple of the left breast, which was less distinctly cancerous, only because it was more movable than that in the substance of the right mamma. In this state I took charge of the patient. Cancerous enlargement and hardening soon appeared in a gland behind the edge of the left pectoral, and that whole muscle was raised by œdematous swelling. Meanwhile every trace of the doubtful cancer of the left breast disappeared. The swelling of the left pectoral region next diminished, and there remained on that side only a very hard gland of the size of a nutmeg. The primary tumor on the right side, which had meanwhile remained without increase, resumed its growth, as the activity of the disease on the left side abated; and after nearly doubling its size, it in turn stopped growing, and partly but decidedly shrank.

A woman, aged forty-six, suffered from cancerous tumors in both breasts, and similar infection of the axillary glands. For many months the primary and secondary tumors in the thoracic region lessened, ceased to be painful, and two of them became so soft as to appear as if they had been mere inflammatory indurations of breast-tissue. But during the same period she complained of incessant pain in the loins, and subsequently in the dorsal region, the cause of which became manifest as cancerous infiltration of the bodies of the vertebræ, two curvatures forming in the dorsal region, and temporary numbness occurring, with loss of motive power of the lower limbs. A strongly pulsating cancerous tumor also protruded from the sternum. In these, and in other cases of withering of cancerous, and especially of primary, tumors, which I have had the opportunity of observing, the diminution was attended either with a growth of cancer elsewhere, or with development of tubercle in the lungs; never with what could be supposed to be a spontaneous cure of cancer. The closest outward observation furnished no clue to the mode in which the growth of the primary cancer was arrested. All were cases of primary cancer of the mamma. No pressure was made upon them. Two subsided under the long-continued application of an opium plaster; and the recurrence of the disease in one was in the vertebræ, and in the other in the uterus; a third withered without any external application, during

an exuberant growth of cancer in the axillary glands; another, during acute tuberculosis of the lungs.

The *size* attained by different primary cancers varies greatly. It is not an accident, determined by the amount of nutrition available in the part, but is a measure of the vigor of growth possessed by the tumor. Hence it happens that a primary scirrhus in the mamma of one patient may not exceed the bulk of a walnut, while that of another patient may be attaining five or six inches in diameter. When a primary scirrhus remains so small as that first mentioned, its growth has probably been arrested; the other, growing throughout its substance to a large size, is often of a strange shape. In a few of the cancers of the intestinal canal and of the uterus, the total amount of deposition in the form of tumor throughout the body is small; yet death ensues without obvious derangement, but with a permanent quickness of the pulse, loss of appetite and spirits, sallowness, emaciation, and a thin, watery, and pale condition of the blood.

The cancerous *ulcer* is often a small and superficial breach of the surface, which remains long hidden beneath a dry scab. When resulting from the discharge of softened parts of a scirrhous tumor, it is at first a deep cavity, with sharp rugged edges and a base of slough or of large prominent cancerous granulations; the discharge from it is thick and muddy, or purulent, or sanious, and is always offensive and peculiar in smell. With cancers of the breast in such a condition, many women present themselves for admission to hospitals; their countenances haggard, unable to sleep on account of pain, feverish, without appetite, and equally depressed and ill in body and in mind. Under suitable treatment for a few weeks, processes of repair will have sprung up in the very centre of the cancer, and changed such an ulcer into a cicatrizing and scarcely painful sore. The health and spirits may be renewed, and the patient even gain flesh. No credit is due to the surgeon, however, beyond that of having judiciously managed the general health; for temporary improvement of this kind will often occur with various treatment, sometimes even with none but home-comforts and repose. The deposition of fresh cancerous matter continues beneath the growing or the finished scar, and painful sloughings, new softenings, or partial inflammations occurring during the very continuance of the improvement in the general health, and again interrupting it, betray the fact that surgery has no real control over the advancing disease.

The *cicatrix* of a cancerous ulcer is easily recognized. It is extremely thin, red or violet in tint, and often traversed by large visible vessels. Unlike the scar of a mere wound or simple ulcer, which tardily and rarely rises over exuberant granulations, or dips into hollows, the cicatrix of a cancerous ulcer advances in spite of the inequality of the surface of the sore. Being also incapable of drawing in by its contraction the surrounding firmly adherent skin, it is apt to become extremely tense, and more and more attenuated. It is consequently very liable to ulcerate afresh, and especially so if to its own natural tension be added that arising from a renewed growth of the tumor beneath it. This description does not apply to the scar which closes the space left by the total disappearance of a former ulcerated cancer. The process of cicatrization is in that case natural, so far as the tissues are free from remaining cancerous material.

2. The other form of primary scirrhus differs in the mode and the amount of its growth from that already described. Having the same power of involving and spreading to new tissues, it does not accumulate its material in a central tumor, but travels superficially in all directions from its original situation. Like erysipelas or phagedænic ulceration, it spreads to new tissue and leaves that which was previously diseased. On the surface of the thorax may then be found a central red thin scar, adherent to the walls of the chest, ulcerated, and perhaps sloughy at its outer part, and skirted on all sides by shallow crescentic plates of dense scirrhus, which are slowly advancing by fresh deposition in the surrounding healthy skin and tissues. Such cases of scirrhus appear to involve only the skin, and are sometimes described as cutaneous cancers. Although, however, they may originate in that structure, they occasionally spring from the deeper parts, and they always involve and destroy them. Of the mamma, in advanced cases, no vestige is to be found. These phagedænic cancers, as distinguished from the tumors, are among the slowest of all cancers in their progress. Two such died in the twenty-third and twenty-fourth years of the disease, and after more than twelve years' residence in the cancer-wards of the Middlesex Hospital. From one of them a tumor of the breast had been twice removed, and she had remained well for nine years before its reappearance as a spreading cancer of the kind now under consideration; the other appears to have had only the creeping superficial disease from the first. The mode of her death has been already related in the paragraph on sudden outbreaks of cancer-growth in the course of the more chronic form of the

disease. The disease known as Jacob's Ulcer of the face corresponds so nearly with this form of cancer that I have ventured to describe it under that name.[1]

Scirrhus infects the absorbent glands which are anatomically associated with its site. The scirrhous matter has been demonstrated not only in the glands, but also in the lymphatic tubes leading to them. The period at which cancer is first formed in the glands is uncertain; but it may be very early indeed. They may be decidedly tender before being perceptibly enlarged or indurated. Often, indeed, if not commonly, the first change is rather a diminishing than an increase of their bulk, and a rounding of their form with bullety hardening. Few cancers are met with in which the glands are not already affected, however recent the primary disease, and still fewer in which they are not involved at the time of death.

In early scirrhus of the breast it may be impossible to distinguish the infiltration of the axillary glands, but some cancerous deposit may yet appear in one or more of them at the subsequent operation. So early do they become infected, that they may be the first indication of the nature of the disease. Mr. Vincent[2] describes his detecting cancer as the cause of some obscure uneasiness in the throat, in consequence of observing one or two small glands, as hard as shot, in the lower part of the neck; and most surgeons have doubtless discovered the malignant nature of a stricture of the œsophagus by the same means. From the very early period at which the absorbent glands are affected, they sometimes appear to be alone, or primarily, diseased. Cancerous axillary glands may thus be already rather large and growing before there is any trace of the primary cancer in the breast. Both mammary and axillary tumors afterwards take the ordinary course of scirrhous cancer, with the exception that the latter throughout remain by far the larger tumor. This circumstance, however, could not be relied on as fixing the origin of the disease in the glands, since it is certain that predominance in size is not essential to distinguish the primary cancer.

The infiltration of absorbent glands with cancer renders them after a time unfit to perform their functions, and they become permanent obstructions to the course of the fluids which should traverse them. Partly on this account, and partly from narrowing and plugging of the adjoining veins, the current of healthy lymph from unaffected tissues, and of the cancerous material arriving from the primary tumor, are both arrested, and accumulate behind the obstruction. Thus when the axillary glands are thoroughly cancerous and impervious, œdema ensues not only in the breast, but also in the upper extremity. An instructive contrast is then observable in the condition of these two parts. The arm becomes simply œdematous; but the fluid from the breast, being cancerous, occasions the growth of great numbers of cancerous tubercles in and beneath the skin of the whole region between the primary and the lymphatic tumors, as well as of a wide area on the side of the trunk and over the scapula. Hence arises the firm combining and matting together of all the natural tissues into the state termed "hide-bound," and a distressing compression of the thorax. The copious cancerous fluid finds its way by anastomosing absorbents to distant parts of the lymphatic system, and the inguinal and higher cervical glands on the same side as the primary cancer, those in the axilla of the opposite side, and thoracic and even lumbar glands, become filled with cancer. Secondary tumors may then form in the opposite breast; but occasionally the lymphatic glands in that axilla become cancerous without any previous affection of the breast. This mode of the extension of cancer, by however widely spread an infiltration around a primary tumor, may be distinguished from that which is due to the carrying of cancer material to distant parts with the blood, and from the spontaneous growing of a new tumor in a distant organ.

If a scirrhous cancer in an early stage of growth be cut into in the living person, it is found to require a firm incision; to become concave on both its cut surfaces; to open with difficulty unless completely divided; to bleed from its whole surface uniformly, without jet, and more freely than the textures around it; and to be incapable of enucleation. When examined after removal, it is seen to be indistinct at its surface from its union with the adjoining tissues, portions of which are a little prolonged into its substance. With the exception of being concave, the section is smooth and glistening. The hollowing or drawing in of the surface of a section is a character peculiar to scirrhus; no other tumor presents it, and in scirrhus it is not invariable. A somewhat similar central depression is observed on the uncut but flat peritoneal surface of a nodule of scirrhus in the liver. The cause of this phenomenon is not clear. The degeneration of the older central parts of the tumor does not explain the pitting, and it appears to be of the same nature as that which draws in adjoining structures external to the tumor, and to be especially

[1] Rodent Cancer, by Charles H. Moore. Longmans, 1867.

[2] Observations on Surgical Practice, p. 352.

a quality of the outermost and growing part of the tumor. The color of the section may be uniform, and light bluish-gray or buff-gray, according to the preponderance of cells or fibres in its minute construction, or it may be streaked with interlacing lines of fibrous tissue, or marked with yellowish dots and short stripes. Upon scraping the surface of the section, a thick creamy juice can be removed, which is bluish, or whitish, or tinted red by an admixture of blood, and is more in quantity in proportion to the bluish-gray hue of the section, as well as to the length of time which has elapsed since the removal of the tumor. It is most abundant when decomposition has commenced. Most of these characters may be also noticed in a cancerous axillary gland, the disease in it usually exhibiting much the same appearance as the primary disease in the breast. There are, however, varieties in different instances. The section of the glandular cancer is not concave. The yellow dots and lines sometimes exist only in the primary tumor, sometimes only in the glandular secondary growth. Fibrous lines are most common in the primary growth, being probably a part of the tissue of the invaded organ; and they do not occur at all in scirrhus within a bone. At a later period, the primary tumor may be much altered from its first appearance. Extravasated blood may tinge a part of the section with any of the various colors which blood assumes; inflammation may attack a part of the tumor, and, pouring into it some of the inflammatory effusions, soften and discolor it; cysts may appear in the midst of the cancerous mass, though they are more commonly found in adjoining breast-tissue, and modify with their various contents the appearance of the section; the tumor may be surrounded by a cyst, and be attached to its wall only by a broad base; portions of its centre may be occupied with colloid; and it may itself have spontaneously degenerated, and present here and there on its section buff-colored or whitish creamy portions of so-called saponification of the tumor, or of the softening already described. The partial mortifications which result from inflammation or injury, or which befall prominent and ill-nourished parts of the tumor, and the changes incident to the requisite processes of repair, further modify the appearances of the section of a scirrhous tumor.

For the usual appearance of scirrhus under the microscope, see Figs. 40, 41, 43, 45. The drawings show that the withering of a cancerous tumor is not a conversion of it into other tissue, or a return to healthy structure; but it is a cessation of the growing of the tumor, and a destruction of its elements. Cells and nuclei break up, oil-globules and granules escape. The chief element in a withering cancer is fat, which is remarkable when there is a general emaciation of the body.

The effects produced by scirrhous tumors are as various as the organs involved by them. In bones, they give rise to spontaneous fractures; in canals, to stricture, and even complete occlusion; in the brain, spinal cord, and trunks of nerves, to compression and other changes, which are manifested in the anæsthesia and paralysis of subordinate parts. These and many other effects may be studied in the essays devoted to the diseases of particular organs.

For the same reason, reference may be made to those articles on the subject of special diagnosis. Little need be added beyond what has been already said to distinguish these tumors. Hardness, adhesion to the nearest textures, with consequent pitting of them or immobility, according to the texture involved, irregularity of surface and still more of shape, uncertain number in an organ, early freedom from pain, ordinarily slow growth; such characters usually suffice to distinguish a scirrhous tumor. If it have arisen in middle life, and in the female sex, the diagnosis is nearly certain. It may be quite so if attention be further directed to the pain and the condition of the absorbent glands. Often, indeed, pain scarcely exists in an early scirrhus, but handling it brings on soreness, and a sudden, sharp, vibrating or lancinating pang, which darts from the tumor in various directions. As the tumor grows, this electric sort of pain becomes more established and more severe, often spoiling the patient's rest. It is decidedly more severe than in the softer and more rapidly growing examples of cancer, and is probably due to the compression and dragging of the nerves, as they become involved in the contractile scirrhus, and to the interstitial deposit of cancer-structures amongst and between the nerve-fibrils. But the state of the glands is almost pathognomonic. No innocent tumor is accompanied with a similar enlargement or hardening of them. The only condition on which they are ever found diseased in connection with an innocent tumor is, that the skin covering it should be ulcerated, blistered, or otherwise irritated. Even in the difficult diagnosis which has sometimes to be formed between the early cystic and the cancerous disease of the breast, as well as when both are met with in the same breast together, the disease of the glands is always found to strictly coexist with the cancer.

Medullary cancer.—The disease so named acquires its title from the brain-like appearance of its section. It is for the same

reason as often called "encephaloid," or in respect to its density it is contrasted with scirrhus by the title of "soft cancer." To certain forms or accidents of the growth are attached peculiar names, as Fungus Melanodes or Hematodes. The structure of these tumors, however, and the manner of their growth and life, are not essentially different from one another.

If it were not that the soft cancer is sometimes found associated with scirrhus, these two diseases might be looked upon as essentially distinct. In fact, however, they sometimes coexist and are both actively growing in the same body, or after the extirpation of one the recurrent disease in the internal organs may assume the form of the other. The sequence in such cases is always from scirrhus to encephaloid, which thus, and also when it is the sole disease, must be regarded as more serious than the hard cancer, and as inducing and implying a deeper taint of the system. It is almost exclusively the form in which cancer occurs in young subjects; it may exist at birth, and it has even been met with in the fœtus.

The encephaloid forms tumors of larger size and greater number than scirrhus, is much more rapid in its growth, and more speedy in its fatal issue. It produces a greater exhaustion and a more decided constitutional cachexia than scirrhus. It exhibits none of the peculiar quality of the hard cancer of drawing towards it adjoining textures, but rather distends and thrusts them aside by the rapid and great accumulation of cancer-materlal in its tumors. The natural structures are therefore sometimes as much attenuated and mortified by the expansion as they are involved in the outgrowings of an encephaloid tumor. Indeed, some of them are invested and almost completely isolated from the tissues in a distinct capsule. Mr. Paget describes such an one as having been laid bare by ulceration of the skin, and then squeezed out upon some exertion by the muscles of the back, amongst which it lay. Apparently in consequence of this rapidity of growth, medullary cancer at first spreads chiefly through the loose cellular tissue, and does not at once, like scirrhus, involve and destroy the adjoining firmer textures. It sends prolongations into cellular interspaces or grows round organs, as bloodvessels, which can for a time resist its aggressions. Eventually, as may be well seen in the lung, they also are destroyed by the cancerous growth. When situated on the surface of an organ or cavity, it is apt to protrude and form a tumor of greater diameter than its surface of attachment. This occurs in the bladder, within bloodvessels on the inner wall of some ovarian cysts, and rarely, but unquestionably, within some of the cysts in the breast.

The situations in which encephaloid is most commonly met with by the surgeon are the limbs and the breast. In the latter situation it is very far more rare than scirrhus; in the former, it selects the intermuscular spaces and the cancellous extremities of the bones. The eye, the testis, the uterus, the bladder, and the cavities about the face, are also occasionally the seat of medullary cancer. It forms swellings which are at first deeply seated, indistinct, and cognizable rather by local tenderness than by the amount of their enlargement, but which afterwards become masses of very considerable bulk. Except where it is covered with bone or bound by tense fascia, the mass rises towards the surface in large and sometimes numerous globular projections, which are unequal in their density, but always soft as compared with the base of the mass, and are not unfrequently so elastic as to give the impression of their being cystic. So delusive is this feeling of elasticity, and so difficult to distinguish from the fluctuation of a thick fluid in a tense cyst, that surgeons are sometimes induced to puncture one of the projections in the expectation of finding matter. The escape of blood only at the time, and the subsequent protrusion of a soft bleeding fungus through the aperture, betray the real nature of the case, and show that the surgeon has but anticipated the natural progress of the disease.

One chief characteristic of encephaloid is its great vascularity. It is traversed by very numerous and thin-walled vessels of enormously disproportionate size; and it appears to occasion in the adjoining structures a very great increase of existing vessels, if not the development of new ones. So commonly is the skin covering a medullary cancer marked by very large and tortuous veins, that their absence may throw doubt upon the nature of the tumor. It is important therefore to add that the superficial veins are sometimes not much enlarged. This was the case with a boy of twelve years of age in the Middlesex Hospital, whose leg was amputated at the knee-joint by my colleague, Mr. De Morgan. The tumor was nearly as large as a cocoa-nut, and was ulcerated; yet the veins, though visible, were neither numerous nor much enlarged. Upon this great vascularity of medullary tumors, and manifestly upon the enlargement of their arteries, depends the remarkable fact of their occasional pulsation and aneurismal sound. A medullary tumor traversed by large and thin vessels, surrounded, except on one side, by bone, and bound down by periosteum, may pul-

sate on that, the only side which can yield. And it does so pulsate with very considerable force, receding like exposed brain and becoming distinctly softer during the systole of the vessels. The most common instance of pulsating cancers is that in which the tumor is formed within a bone, and I have observed the fact in the sternum, ilium, and femur; it has, however, also occurred to me in a case in which the tumor was placed in contact with large arteries beside and externally to a bone. In some of these instances the pulsation was not distinguished from that of an aneurism, and the operation for that disease was performed. (Medico-Chirurgical Transactions, vol. xxviii., p. 303, and vol. xxxv., p. 459.)

Ulceration is, in many medullary cancers, the signal for the occurrence of frequent and severe hemorrhage, and for a rapid outgrowing of soft, fungous blood-colored protrusions. These are sometimes so exuberant, and their substance when examined in section is so deeply stained, that their form and character led to their being specially named by Mr. Hey *fungus hæmatodes*. Both the hemorrhage and the overgrowing are mainly due to the great size and thinness of the walls of the bloodvessels in the tumor.

Encephaloid cancer arising in or from a bone presents a character which is never seen in scirrhus, viz., ossification in its interior. The new bone could not possibly be mistaken for the old; it grows out in long spines and flat plates, radiating in all directions as the stroma, or spreading fibrous septa, of the growth direct it. It appears, in fact to be an ossification of the fibres and bands of tissue which divide and subdivide the tumor. The quantity of new bone varies greatly; there may exist only a few scattered pieces, or the stroma may be completely ossified, and the bone alone retain, after maceration, the shape of the cancer. The existence of a plate of bone in the capsule was the principal indication that one of the pulsating tumors which have been referred to was of cancerous, not aneurismal, nature.

Equally peculiar is encephaloid in respect to its course. No form of cancer can be more rapidly fatal, none of longer duration. On an average of cases, medullary cancer runs its course in about two years, whilst scirrhus extends to three or four years. Isolated instances of the medullary form of disease may be more rapidly fatal than any of the scirrhous variety, or of longer duration, respectively. One case observed by Professor Gross in the New York Hospital, an instance of medullary cancer in the scapula of a lad, ran its entire course in eight weeks. Mr. Paget has informed me of the case of a gentleman, aged 16, who was apparently well and playing at cricket seventeen days before death from medullary cancer of the small intestine, which rapidly extended even to the diaphragm. In another case of multiple encephaloid tumors, a mass in the arm, which was found after death to be entirely made up of soft cancer, was said by the patient to have existed for thirty years; a longer period, if it had been all that time cancerous, than that of any other form of the disease.

Medullary cancer in the absorbent glands is a repetition of that of the primary tumor; it is soft, usually larger and more rapid in its growth than glandular scirrhus; but on the whole less prone to take on that exclusive growth which gives to secondary hard cancer the appearance of superseding the primary tumor. The medullary disease is at least as apt as scirrhus to spread extensively through the absorbent system.

The pain of encephaloid is generally less severe than that of scirrhus, and its tumors bear an amount of handling which would occasion much suffering if they were of the hard variety. Nevertheless it is advisable to avoid such handling, since there is no tumor from which soft dislodged fragments are more readily disseminated. In scirrhus the pain appears to be more definitely seated in the tumor, and to radiate from it, or to extend along the nerves connected with it. That of the medullary variety seems to be chiefly the effect of the tension of the nerves and other adjoining parts, the tumor itself not being sensitive. I recollect, before chloroform was introduced, seeing an attempt to extirpate a very large medullary cancer from the side of the neck. The girl expressed much suffering as the parts all around the tumor were cut; but when, in consequence of the impossibility of disengaging prolongations of the tumor from the transverse processes of the vertebræ, the operation was to be abandoned, and part of the tumor itself was sliced off, scarcely any complaint escaped her, and it was evident that the cancerous mass was but little, if at all, endowed with feeling.

No tumors present a greater variety of appearance upon section than those of soft cancer. Differences of structure occasion many of these varieties, and others arise from the fact that, being abundantly supplied with blood, the tumors are exposed to all the changes and accidents which great vascularity involves. The growth and the decay of the cancerous structure itself, inflammation, suppuration, effusions of lymph and serum, hemorrhages, and all the consequent changes of tint and density of substance, diversify greatly the appearances of medullary cancers. The arrangement in lobules is commonly found to ex-

tend throughout the mass as well as on the surface of medullary cancer, and strong septa part the lobes from one another. In respect to differences of structure, it is important to observe that tumors which have not the brain-like aspect are classified by pathologists with medullary cancers, because of their likeness in microscopic structure and their clinical history. The cancers whose stroma is branched, and their name dendritic, are of this class. Some of them are firmer than the ordinary soft cancer, and are compared to such objects as udder, placenta, and potato. The "albuminous sarcoma" is probably of this nature. When scraped or squeezed the softer varieties yield abundantly a thick creamy juice, the microscopic appearances of which are shown in Fig. 42.

Operations on medullary cancers are apt to be followed by a very rapid and destructive reappearance of the disease; yet in no form of cancer is the advantage of surgical interference sometimes more manifest. Life, on an average, is considerably prolonged by the removal, and sometimes repeated removal, of the primary tumor. In the museum of the Middlesex Hospital (Nos. *118, 119, 120) are the wax models of a woman's leg, the middle and outer part of which had been occupied by a very large and rapidly growing soft tumor. The section shows it to be entirely superficial to the fascia, and to be of venous-blood color, very soft, almost pulpy, and streaked with large thin-walled vessels. The limb was removed above the knee, and in the stump there soon appeared livid blood-colored tumors as large as plums, which rapidly grew, and could not be distinguished before or after section from fungus hæmatodes. The limb was amputated a second time, and the patient was alive seven years afterwards, and free from disease.

Melanosis.—There is little in the structure or course of this form of cancer by which it could be distinguished, beyond the very remarkable character from which its name is derived. A tumor, otherwise medullary or epithelial, is in melanosis blackened more or less deeply with pigment, and presents accordingly various degrees of blackness, from that of jet to a mere staining, through which the color of the tumor is distinguishable. That which is still more remarkable, and which shows the pigment to be no essential element of the cancerous structure, is that sometimes portions only of the tumor are thus tinted, and that distant parts of the body, presenting in other respects the appearances of perfect health, are irregularly stained and smudged in the same way. The blackening is due to the presence of pigment, which is partly contained within the cells of the cancer, and partly free. (See Fig. 44.) It may be supposed that this pigment, formed in the tumor, has been conveyed with the circulating blood into bone, skin, uterus, liver or other structure, and has mechanically stuck, and then, perhaps, multiplied there. In a case of extensive melanosis in the Middlesex Hospital, in which the liver weighed nine pounds, large granular cells containing pigment were discovered with the microscope, not only in the fluid squeezed from the solid structures, but also in the dropsical serum of the abdomen, and in blood taken from the external jugular vein.

The most frequent situation for the growth of primary melanosis is the skin; and those tumors are the most likely to contain the black pigment which originate in persons of dark complexion or near moles. The eye, in which also pigment naturally exists, is likewise subject to primary melanotic growths. Black cancers occur much more frequently in the horse and dog than in man. As a general rule, in fact, primary melanosis occurs only where pigment already exists.

The effect of removing the primary growth is not less favorable in melanosis than in other cancers. In a man who died under my care with melanosis of the left inguinal glands, and very many other melanotic tumors in the left thigh, liver, etc., the primary tumor had been removed from the scrotum by ligature, and a little pigment only appeared in the white and otherwise healthy scar ten months after the secondary disease had commenced in the groin. In another case in which I removed a melanotic cancer of the anus, the microscopic characters of which were medullary, the man was at once relieved of excessive local suffering, and he passed thirteen months of healthy useful life before the disease returned in the part. He was still alive twelve months after its recurrence.

Epithelial cancer. — The disease thus named is also known as epithelioma, or cancroid. The microscopic cells which pervade it differ much less than those of scirrhus and encephaloid from the cells of the part in or near which they grow; and their likeness to the natural epithelial structures has gained for the disease the name by which it is most commonly designated amongst British surgeons. (See Figs. 47, 48, 59, 60, 61, 62.) And as its minute structure deviates least of all the cancers from the natural tissues, so its course and history often exhibit in the least degree the character of malignancy. In being a solid infiltrating growth, prone to ulcerate in its older part, ever extending into and destroying new and various

tissues, capable of infecting the glands, and of transference so as to form a new tumor in a distant organ, it is clearly cancerous in nature, though in appearance it is sometimes scarcely distinguishable from the severer forms of lupus. The Rodent facial ulcer appears to the writer to be a form of this disease, differing in no degree from epithelioma in the amount of local destruction it produces, but much in being more chronic, less solid, and not prone to grow into tumors in the glands or in distant organs.

Epithelial cancer is more frequent in the male, as is scirrhus in the female. Its chief primary site is the skin, especially at or near the mucous orifices ; it is apparently capable of growing on or near any orifice which is clad with epithelium, and it is accordingly met with on the edges of the mouth and eyelid, the anus, vulva, prepuce, and scrotum. It is eminently a cancer arising from a local cause, having almost an exclusive preference for the lower of the two lips, and of the eyelids. Although not an uncommon disease of the buccal mucous membrane near the salivary duct, it is unknown in the nostrils and air cells of the head. It originates also on the skin, on the tongue, on the os uteri, but not on the vagina, and it sometimes attacks old scars, chronic ulcers, and sinuses. A specimen, apparently, of this disease was presented to the Middlesex Hospital by Mr. Arnott ; it forms a large tumor infiltrating a female breast, and in great part excavated by an uneven papillated cyst. The cavity was filled with a thick closely-packed mass of epithelial scales, and the disease appears to have originated in the mucous ducts. The cauliflower excrescence of the os uteri is of the nature of epithelial cancer, and the name well illustrates the fissures and branching of the growth, even to its root. On the scrotum it forms the well-known chimney-sweeper's, or soot, cancer of Mr. Pott.

Epithelial cancer makes its first appearance in various forms. In a recent case at the Middlesex Hospital, it grew as a warty excrescence from the nose, and spread slowly over the centre of the face until it reached the size of half a swan's egg, when the patient died. The entire surface of the growth was made up of separate pedunculated rounded tumors no larger than peas, and covered with thin integument. Occasionally the surface of the growth is thickly set with straight, short, and stiff papillæ. Sometimes there is little apparent but a fissure, covered with a dry scab ; and on pressing it the fissure is found to be a cleaving of a superficial but firm, or even hard, thickening at one of the mucous orifices. It may form a single pedicled outgrowth, or be an infiltration of all the superficial structures, assuming the shape of a flat, firm, sessile tumor. In the tongue it is now and then found to be deeply lodged, of considerable size, and, only as it enlarges, to approach the superficial epitheliated membrane.

The entire substance of all these growths is microscopic cells, which differ little in appearance from ordinary epithelium, but hold a different relation to the natural tissue. They do not clothe its surface, but, after the manner of true cancer, they infiltrate and destroy the deeper parts, being traceable even into the midst of textures with which they have no natural relation.

Like true cancer, the epithelial growth softens, ulcerates, or sloughs, and a characteristic ulcer is the result. It is apt to be covered with a creamy juice, which hides the pale pink surface of the sore, the pea-shaped tuberous granulations, and the deep fissures which part larger inequalities and bulging outgrowths of the ulcer. The edge is thick and often raised, and a thin cicatrix not uncommonly advances far over the sore. A whole ulcer may thus cicatrise, and fresh ulceration subsequently take place in some adjoining portion of the tumor, or some entirely separate deposit. The appearance sometimes presented on the skin is hence very varied ; as on the leg, the greater part of which may show, with many present epithelial ulcers, the marks of much previous, but now scarred, ulceration. In many cases the cancer early leaves the surface, and grows and ulcerates deeply. The subsequent destruction of the natural tissues is occasionally very extensive ; one cheek and half the jaw, or the entire tongue, or the whole thickness of a tibia, or all the structures composing a joint, being removed by it. It tends early to infect the subordinate glands, at first rendering them hard, round, and bullety, but afterwards growing to enormous soft tumors, in which all trace of gland-structure has long been lost. These, in turn, ulcerate at one or more points ; but the small external opening, with its bulging edge, is seen to be the outlet of a large cavernous excavation, which eventually, as the ulcer widens, is laid broadly open. The epithelial is less apt than the other forms of cancer to be limited in the lymphatic system to one chain of glands. It is also peculiar in being rarely disseminated beyond that system into distant organs. When that occurrence does take place, the form of the diffused disease is, as a rule, the medullary. The fatal result is almost always due to the secondary glandular affection, the excessive growth and widely spread ulcerations of which exhaust the

system much more than the smaller primary tumor.

Great vascularity almost only occurs in the medullary form of cancer. I have, however, once seen in an unquestionable case of epithelial cancer of the lip a growth of vessels and a liability to copious bleedings, which might have characterized the disease as medullary. The whole skin of the front of the neck and upper half of the thorax became a vast purple nævus, uneven from the bulging of large vessels, soft and impressible as a varicocele, and presenting no trace of the natural hue or thickness of the cutis, except at its edges, where it blended irregularly with the unaltered integuments. The patient was an old man, and the whole nævus formed in a few months, under my own observation.

Both in its long average duration and in the numerous instances which it presents of a considerable interval between the time of excision and that of the return of the disease, epithelioma manifests a less pronounced malignancy than the other forms of cancer. Mr. Sibley deduced from the Middlesex Hospital records,[1] that, on an average, the epithelial cancer destroys life in fifty-three months, while scirrhus lasts but 32.25 months. The fact, regarded alone, might seem to be accounted for by the rare occurrence of secondary epithelial cancer in the vegetative organs; but when the familiar observation is added, that many patients, from whom this form of cancer has been removed, remain for years without any recurrence of it, and that recurrence is not usual in the scar, the conclusion seems fair that it is essentially less inimical to life. One reason of the comparative immunity of the superficial parts from a recurrence of the primary growth may be that being usually but shallow, it is less often incompletely extirpated.

The epithelial is the only form of cancer, the origin of which has been satisfactorily associated with previous local disease. Instances are common in which it unexpectedly appears in parts which have been long subject to irritation, or have been the seat of unhealthy and ineffectual attempts at repair. Dr. J. Moore Neligan observed a marked whiteness of the surface of the tongue and cheeks for some years before the outbreak of cancer on those parts. Mr. Shaw has published an instance in which epithelial cancer suddenly appeared in an issue which had been kept open for thirty-five years. In another instance he amputated the arm of a gentleman, aged thirty-five, for epithelial cancer which had invaded an old diseased elbow-joint, rapidly destroying bones and soft parts alike. The original disease dated from the patient's childhood, and had long appeared to have ended in anchylosis, a small fistulous opening only occasionally discharging matter. The disease returned in the axillary glands, and the patient eventually died. Mr. Oliver Chalk successively amputated both the lower limbs of a man in whom bunions, after remaining for many years unhealed, had become affected with epithelial cancer. The same disease came on in an unhealed surgical wound in the perineum, three months after the section of a strictured urethra by Mr. De Morgan.

The following case illustrates the same fact. It shows also the possibility of the complete subsidence of the primary disease, which has been already related of scirrhus. Its occurrence in medullary cancer is doubtful, or extremely rare. A sallow man, aged thirty-five, was under my care in the Middlesex Hospital for a large ulcer of five years' duration on the right leg. It had the ordinary characters of a vast chronic ulcer, except at the outer and lower part, where, and where alone, the granulations were tuberous and hard, and the edge, quite unlike the white callous margin of the rest of the sore, was thick, everted, and red. Below that part of the ulcer which appeared cancerous, the skin was harder than elsewhere and raised in a few nodules. The thigh was œdematous, the leg slightly so, and in the iliac region could be felt a mass of enlarged and hard glands, as large as a hen's egg. The urine was albuminous. In the course of five months of treatment, the urine ceased to contain albumen, the nodules and swelling of the granulations and skin, which had been unmistakably cancerous, disappeared, and the sore entirely healed. But in the same period the glands in the groin doubled in size; one or two of them became as large as walnuts, and the œdema greatly increased, distending the entire limb. Mr. Pollock informs me of an instance of the entire subsidence of what appeared to be cancerous infiltration of the inguinal glands, subsequently to his amputating in the thigh on account of a primary epithelial cancer of the leg.

Osteoid cancer.—It has been stated in the description of encephaloid cancer, that the stroma of that growth is sometimes ossified, and traverses it in the form of radiating plates and fibres of bone. Examples of ossification have also been mentioned as occurring in tumors originally fibrous, cartilaginous and myeloid, as well as in others. Osteoid cancer, however, differs from all these. In a well-marked case the primary tumor is a mass of the hardest enamel- or ivory-like bone; the glandular disease is bony, though it may be less hard; and the disease disseminated in the soft internal organs, and protruding into the bloodvessels, is also in great part osseous. The surface and portions of the interior of the primary growth may be unossified, and composed of the very densest fibrous struc-

[1] Med.-Chir. Trans., vol. xlii., p. 125.

ture. The first tumor is usually single, slightly uneven on its surface; its section, though in parts fibred, is mostly very compact and unmarked by canals: the secondary growths are less solid, and separate or crumble to pieces after maceration. The bone is quite white: its microscopic elements are in some parts arranged in the manner, but not with the perfectness, of true bone.

Though wholly different in texture from the ordinary cancers, this rare disease resembles them in its clinical progress, and it is sometimes associated, not to say interchangeable, with encephaloid. Fig. 49 represents the bony elements of a secondary osteoid in the lung, but mixed with cells of cartilage and spindle-celled sarcoma. Langenbeck informed Mr. Paget that he "once removed an upper jaw with a bony growth, and the patient died soon after with well-marked medullary cancer in the lungs;" and that "he once removed a humerus with a medullary cancer, and the patient died with osseous tumors in the lungs."[1]

Primary osteoid cancer occurs usually in bones, and especially in the lower end of the femur. It may occupy the interior or the exterior of the bone, or both parts. Some such tumors have been met with in the interspaces of the structures in the limbs. Its growth is usually rapid and very painful. Mr. Paget describes a case in which death took place in three months and a half after the discovery of the primary tumor, but refers to seven others which were operated on, in two of which the disease was fatal in the first year of its existence, in one in the second, and in one in the third; whilst one of the seven patients lived seven years and a half, another for twenty-four years, and another for twenty-five years. The evidence is decidedly in favor of early and of repeated operations in this disease.[2]

Of *villous* and *colloid* it is not easy to speak as cancer. Some authors regard colloid as of that nature, and as sometimes concurrent and interchangeable with medullary cancer, as even forming one part of a tumor which is elsewhere malignant; others, and particularly Mr. Sibley,[3] not denying the latter fact, restrict the term to cases which they find capable of classification by their microscopic appearances, and not prone to multiply, or to infect the constitution. Nevertheless the clinical course of the two subjoined cases resembled that of cancer. The characteristic of its construction is a very delicate translucent membranous stroma, which is coiled around spherical spaces, varying in size from that of a blood-corpuscle to that of a hen's egg. (See Figs. 50, 51.) Out of these spaces can be turned a clear, sometimes colored material, as various in its consistence as glue, and having for the most part a plainly perceptible kernel, or central body, composed of granules, or of many, simple or nucleated, spherical cells. The growth of colloid is rapid, and in certain situations, as in the peritoneum, may reach an enormous bulk. The parts in which the surgeon chiefly meets with it are the rectum, parotid region, and breast. Its occurrence is most common in the intestinal canal, where it is also known by the names Gelatiniform or Alveolar.

In November, 1855, I extirpated the breast of a Creole, on account of one of these tumors. She appeared to be about thirty-five, and she thought the disease had existed twelve months. In or beneath her right breast was a hard, much nodulated, tender tumor, flattened and adherent toward the chest. The mamma was lax, and moved loosely over the tumor. The nipple also was healthy and free. She had occasionally felt shooting pains in the tumor, but no severe suffering of any sort. On section the mass was solid, uniform, of a dark pancreatic color, without fibres or juice. It was firmly adherent to the pectoral muscle, of which I removed a considerable layer, and which seemed attached to it as seaweed to a rock. The microscopic appearances were those of colloid only. No cancer-elements existed; yet the disease is reported to me to have returned in the manner of cancer, and she died of it in Jamaica in 1859.

Mr. Douglas, of Hounslow, sent me a colloid tumor which he had removed from a married woman, aged sixty-one. It lay behind the upper part of the tibia, where it had grown in fifteen years to the size of a cocoa-nut. It was deeply lobed, elastic, incapsuled, and painless, but required removal on account of ulceration of the skin covering it. It dipped between the muscles of the calf, without being connected to them, and it was closely attached to the deep fascia. A section of the tumor exhibited the simplest colloid structure, strong septa parting off from one another globules of clear or tinted semi-transparent jelly. The whole tumor was removed; yet within a year the disease recurred in the scar, and a second tumor, a miniature likeness of the first, was removed. A third time Mr. Douglas operated on this growth; and after yet another interval and recurrence, he advised amputation of the limb. The patient, however, went into University College Hospital, where the tumor was removed a fourth time, by Mr. Quain, and the patient died, aged sixty-four, of pyæmia. The tumor last extirpated was a cluster of separate spherical and oval growths, smooth on section, opaque, yellow, and en-

[1] Paget, Surgical Pathology, vol. ii., p. 504.
[2] Paget, Surgical Pathology, loc. cit., p. 495, and Handyside, Osteosarcoma.
[3] Med.-Chir. Trans., vol. xxxix., p. 259.

cysted. It contained free nuclei, tailed and nucleated cells, and other small cells of awn shape with long fibrils. The glands were all healthy, but in the trunk were three tumors; one in the peritoneal cavity, another in the great omentum, and the third in the anterior mediastinum, and among the great vessels. These unsuspected growths were principally fatty, but they presented some of the lobed arrangement of the original tumor; and when boiled in ether, a thin waving stroma was brought out, in some of the spaces of which granular masses, somewhat like those of colloid, appeared. Although, therefore, there was a distant as well as a local reproduction of this disease, it became degraded in the direction of fat, not towards any form of cancer.

Villous growths have also been described as of malignant nature, but with less title to that character than the colloid. There is a villous disease, both in its general appearance and under microscopic examination, extremely like the chorion, and differing little from that natural structure except in the coarseness of its mesh-work and flask-shaped papillary projections. In no specimen which I have examined has any cancerous material been mixed. It springs by a pedicle from surfaces, and in specimens contained in the museum of the Middlesex Hospital its sites are the mucous surface of the bladder, the knee-joint, the interior of a mammary cyst taken from a bitch, and the colon. In the last-named organ the disease covers nearly the whole of the mucous membrane, and its true character is only demonstrable by the microscope. Mr. Quain, however, has published an account of two cases of hemorrhage from the rectum, which arose from single non-malignant tumors of this nature. The ascription of malignant characters to villous disease appears to have chiefly arisen from villi of a hypertrophied mucous membrane sometimes covering the surface of a deeper cancerous tumor, and from the similarity of the symptoms of villous disease and medullary cancer of the bladder. Both diseases grow from the vicinity of the opening of the ureter; both project wholly into the cavity of the bladder; each may have a narrow or a broad pedicle; neither is necessarily single; the amount of secondary disease associated with the true cancer is so small as to be easily overlooked, and confounded with its absence in the villous disease; and the mode of death from the two affections, viz., by hemorrhage and disturbance of the urinary organs, is the same. The cancer, however, has none of the villous structure. It is a soft, highly vascular mass, seldom lobed, sometimes smooth, occasionally having shreds hanging and floating off from its surface. These shreds, however, are without the villous character. They may present the dendritic mode of growth described by Rokitansky, which is sometimes seen in medullary cancers elsewhere; but this branching of the stroma differs from that of the villous disease in appearance, and in the mass of nucleated cells which fill up the meshes of the cancerous structure. The distinctions between villous disease and cancer may be advantageously studied in papers by Mr. Sibley in vols. vii., viii., ix. of the Transactions of the Pathological Society.

[Clinically, we have a pretty clear notion of cancer—it is a new formation destroying the tissues, and after removal prone to recurrence and very liable to metastasis. The class of tumors included under the term cancer, as formerly used, and as here used by Paget, comprehends much more than is understood by carcinomata. All the soft varieties of sarcomata, as well as nearly every other tumor which exhibited destructive tendencies or secondary formations, were included in the class; in fact, cancer signified—and does yet with many surgeons—a malignant growth, malignant either from its leading to death merely, or in the stricter sense of this term.

With the increase of histological studies came the necessity of dividing the growths into classes, and the sarcomatas were separated from the carcinomata according to the anatomical appearances as shown microscopically by each of these varieties. Their characterization by this means has resulted in a partial disappointment, both because the structure of some of the two varieties overlap and so closely resemble or shade into each other as to be difficult of distinguishment, and because certain growths having essentially a like structure do not correspond in their clinical history with others of the same class. We have been compelled, therefore, in order to render more definite our conception of the class carcinomata, to bring into consideration another feature, in addition to their anatomical structure, viz., their genetic relations.

As formerly the "cancer cell" was held to be distinctive of a carcinoma, so until recently the alveolar wall, inclosing the cellular elements, was the structural peculiarity relied upon as characteristic of this growth. Now, however, it is the mode, or as we may say, the history, of the development of the alveolated cell-formation which Virchow has shown us to be the essential feature of a carcinoma.

We can unite "in calling these tumors true carcinomata which resemble in construction the true epithelial glands (not the lymphatic glands) and the cells of which are derived from true epithelia" (Billroth), and we may say that the "greater

number proceed primarily, either from the epithelium-clad surfaces of the body, the skin and mucous membranes, or from the secerning glands, and that they depend upon an abnormal growth of the epithelial tissue" (Rindfleisch). But I take it that it is not in any definition, however cleverly devised, either to convey a definite idea of carcinoma to others, students of pathological anatomy, or to bring about an agreement on the subject among our teachers. A definition is always an unfortunate method of conveying knowledge, since it so constantly fails to express the transition of one formation to another and the processes of their production. The requisite knowledge can only be given by the eye, and we must learn to know a carcinoma as we learn to recognize other objects in the external world. We know a face without being able to define it, and the liabilities to mistaken identity are as great in pathological studies as in the witness box; a very high degree of familiarity will alone protect us from error. When it comes to the discussion of the details of the development of these growths, we require, to meet the problem fully, an acquaintance with both physiology and physiological pathology of the greatest intimacy. To obtain such knowledge we must study the carcinoma in its earliest stage and throughout its life, and not view it merely as a casual spectator views a show, nor must we take the superficial appearances as an expression or exhibition of the cause or the mode of growth of the new formation.

Numerous views have been, and still are held in respect to the histogenesis of carcinomatous growths; some hold that it is a connective-tissue growth—a view which has arisen from mistakenly regarding the alveolar stroma as the typical constituent; most others hold firmly to the epithelioid nature of the new formation, but some consider that the cells develop from connective tissue into epithelioid tissue, while some think that the cellular formation is derived from the normal epithelium, either of the glands or of the epithelium-clad surfaces, and develops in the connective-tissue stroma an atypical epithelial formation; and some hold that the stroma itself is the product of the epithelial cell growth.

Whatever may be the theories held in respect to its development, nearly every one agrees that carcinoma has for its type the normal epithelial tissues, in the same sense that the enchondroma has its type in normal cartilage, or the glioma in the connective tissue of the central nervous system; in every carcinomatous neoplasm, besides these epithelioid cells which constitute the typical elements of the growths, there are other cellular elements present, which are but poorly or not at all represented in normal epithelial tissues. These other cellular elements are invariably seen in the alveolar septa and in the surroundings of the carcinomatous tumor; they occur in greater or less amount, and appear as an infiltration of the connective tissue. These indifferent cells must be regarded as one of the characteristics, since they are never absent during the growing stage of these tumors.

Comparatively little attention has been bestowed on these indifferent cells, but it is from the discussion of the life and activity of these cellular elements, that I think our increasing knowledge of the histogenesis of carcinoma is to be derived. The views that have been held as to the origin, nature, and destiny of these cells, vary with the beliefs as to the histogenetic relations of the chief cells of the morbid growth. Those who consider that the so-called epithelioid cells originate from the fixed connective-tissue cells or from the endothelia of the lymphatics, etc., have no difficulty in accounting for the presence of the indifferent cells. They believe that as a carcinoma is a connective-tissue growth, these cells are of connective-tissue origin and type, and either contribute to the growth by direct transformation, or do so indirectly by an infection communicated from the already developed cells of the new formation. The indifferent cell, therefore, is present as the result of an irritation of the connective tissue. This view necessitates the removal of carcinoma from the class of tumors having an epithelial type. On the other hand, those who hold that the epithelioid cells proceed from the continuous multiplication of pre-existing epithelium, are in doubt whether the indifferent cell precedes the appearance of the new formation or is induced by it, and hence whether it is a wandering connective-tissue cell, or blood or lymph corpuscle or not; some believe that it is essentially an epithelial element which has wandered from the acinus of a gland or from the epithelium-clad surface; some speak of a double nature derived from both sources. According to this view, these cells are either truly "indifferent cells," contributing, perhaps, to the connective-tissue increase or the formation of the alveolus, or else they are an essential formative element, though not the chief one, of the new growth.

Putting aside, therefore, at once, the connective-tissue origin of carcinoma, let us see, from the consideration of normal epithelial growth, what analogies may be obtained for the development of the atypical epithelioid formations. First, let us think of the embryonal origin of epithelia, both glandular and surface; and next of the mode of growth and repair of these

tissues. Unfortunately, embryological studies have not, so far, furnished us with a complete and certain knowledge of the relationship which the outer epithelium-clad surface bears to mucous membrane and to the glandular organs connected with it.

The original view, which taught that of the three primary layers of the blastoderm, the outer forms the skin and its appendages, and the inner the mucous membrane and glandular organs, would lead us to believe that two very similar sorts of tissue, both epithelial in character, were not histogenetically related to each other, and that these tissues, traced back to the segmentation of the germinal disc, were of different origin. The view which holds that all epithelial structures "are produced from one and the same embryonal foundation," and that a "decided distinction is to be made only between epithelia which grow *outwardly*, forming an entire and uninterrupted covering of the integuments and mucous membranes, and those which grow *inwards*, filling up cavities hollowed out in the parenchyma of the body and known as glandular cells or glandular epithelium," is a much more harmonious one, and likewise more conformable to what we see in all pathological processes involving these tissues.

If both the glandular cells and the epithelium-clad surfaces, both integumentary and mucous, trace their origin to the same original elementary parts, the consideration of this chief and all important epithelial neoplasm and its classifications or divisions becomes much simplified, and the distinctions between the two forms usually enumerated, viz., the glandular carcinoma and the epithelioma, become less marked, notwithstanding their different clinical importance.

So far the origin of epithelial tissue, but as to their growth or generation and repair in the adult normal condition, no exact description has been furnished—even less complete knowledge is possessed than of their embryonal relations. According to the terms of the embryological theory of their origin, at the time of the segmentation of the germinal disc, all the epithelioid germs are placed together in one layer, and from this, by splitting or growth inwards or outwards, they finally assume the varied positions in which they are found, and develop into surfaces, membranes, and organs; and here the whole mass of epithelioid germs are permanently confined.

If this statement expresses the whole truth, the further growth and repair must take place by the segmentation or cell division of the original epithelial cells. The epithelial tissues are, therefore, in this respect, different from all other tissues of the body, for in the growth and repair of all the other organs, so far as the process is known, they receive contributions, not merely of nutritive materials from the blood, but of corpuscular elements which are directly transformed into tissue cells. The common opinion is that there are but "two possibilities, namely: either the new epithelial cells are produced by a division of the old, or they arise by pressure behind from the connective tissue." That both possibilities "exist and occur side by side" is easily conceivable, but the "observations of the processes of division of epithelial cells are as yet very scarce." The early observations of Burkhardt and the later ones of Biesiadecki and Pagenstecher seem to remove all doubt that on the skin young cells emerge from the connective tissue, and appear finally as epithelial cells. Still later, Hamilton has shown most conclusively the same process of growth and repair on the bronchial mucous membrane. Some facts, however, known in connection with the repair of epithelial surfaces after a partial loss of their covering, lead to the conclusion that an embryonal (connective-tissue) cell can only become an epithelial cell when it comes in contact with such other epithelial cells. This is the process of so-called *epithelial infection*.

All the theories, therefore, point strongly to the view that the nutritive and the intermediary apparatus, namely the blood and the connective tissue, are the source of both the pabulum for growth and the embryonal formative cells for the repair of all the tissues and organs of the body. The same theories are also held in respect to pathological processes, as well as morbid growths of new formation. Whilst these facts seem pretty plain, the question arises about the essential nature and the intimate or innate tendencies and relationship of the cells, seemingly of connective-tissue origin, which become epithelial. If they are actually wandering connective-tissue cells exhibiting a power to become epithelial, it is necessary to give up all our ideas of the histogenetic relations of tissues. Epithelial infection, a pure hypothesis, does not cover the ground, and is a supposition brought forward to assist in the explanation of certain questions on which no definite knowledge is possessed. Many conditions in which this theory played an important part, especially in the healing of ulcers, are now known to rest on other causes, and above all, it is found that many, perhaps the majority, of the indifferent or embryonal formative cells brought in contact with epithelia are not "infected."

Besides, there is no known instance of

cells changing their nature and becoming other than what they originally were. In the complicated conditions of the animal pathological changes it may be difficult to be absolutely certain of this proposition, but it may be assumed by direct analogies to be correct, from what is known in the simpler relations of normal and pathological growths in the vegetable kingdom. In plants the direct descent of the cells, tissues, and organs can be traced from the period of segmentation to maturity.

To give up the direct descent of cells and to assume another paternity for them, not only involves the disownment of the differentiation of tissues, but must destroy the belief in hereditary transmission of peculiarities and morbid tendencies ; and further, we must believe that cells are what they are according merely to the accidental fact of their position. The difference between a connective-tissue type of tumor and an epithelioid one is merely that of position, and the elaborate classification of neoplasms becomes of little importance ; at most their origin is a matter of chance and position.

The differentiation of the tissues and their morbid growths should not be thus lightly abandoned, without an endeavor to acquire a more consistent knowledge of the mode of the growth and repair and the morbid changes of the epithelial organs of the body. While we may admit the fact that epithelial organs are regenerated from cells which emigrate from the blood, we are not compelled to the belief that the emigrating cells, as we see them passing to and through the various organs and tissues, are all of one sort, and therefore of blood or connective-tissue origin and descent. The blood-current may contain among its white corpuscles not merely germs potential for the formation of epithelium, but corpuscles having the same origin or lineal descent as the cells of the epithelial tissues. It may be—and nothing has been brought forward to the contrary—that not the sum total of the epithelioid germs or cells in the segmentation spheres of the ovum were placed in layers from which the epithelial structure developed. Some of these cells may remain in the blood for the purpose of supplying the growth and repair of these structures. It may be that epithelioid elements in a later stage of development, in fact during all stages of growth, after being originally separated from the blood-cells, become free in the epithelial or glandular tissues, or wander from their seat and are taken up by the lymphatics, and by their agency are returned to the blood-current. This process is necessarily difficult of observation, but is in conformity with known conditions, both normal and pathological, observable in other tissues.

Having thus indicated the existence of epithelial germs or cells in the blood, their origin and direct lineal descent, it is necessary to dwell, for a moment only, on how the germs reach their appropriate place of development. Herein there is nothing to be added to what has already been given concerning the facts observed of the growth of the supposed connective-tissue cell into a young epithelial element. In the blood, as well as on its way to the epithelial site, no distinction or difference of appearance has been pointed out for distinguishing between an embryonal formative-cell of any other type, and a young undeveloped epithelial cell. The distinction between such cells is discovered from their subsequent behavior.

It is especially not intended to be said, or even implied, that the epithelial germs in the blood are drawn out, or are caused to emigrate, through any elective affinity or attraction, or other supposed power, exercised by the epithelial tissues. On the contrary, it is to be insisted on that all varieties of corpuscles emigrate, their number being regulated, increased or diminished, by the formative requirements and activity of a given locality. It is only those originally and permanently possessed of the epithelial impression which develop into epithelial cells ; all others perish or wander back into the lymph and blood-currents to pass on until they find their appropriate seat of development.

How does the genesis of carcinoma accord with this view of the growth and repair of normal epithelium ?

In the first place, when the epithelioid tumor commences its development, let us remember that in the blood-current we have corpuscles potential for the development of epithelial cells, both glandular and for surface growth. Whatever may be the reason which leads to the atypical development of the epithelium into a carcinomatous tumor, I think that the process of its development can be explained more rationally, and the various conflicting opinions now held more entirely harmonized, by the theory of its genesis which is here proposed, than according to any views hitherto offered. It is much more rational to suppose that in normal growth epithelial or glandular tissue is produced from cells or corpuscles, which from the beginning were impressed with an epithelioid or glandular type, than that such tissue could be produced from an indifferent cell having no specific type ; likewise, in morbid growths, it is more rational to suppose that every cell is produced from a pre-existing cell, and that the new cell inherits the type of the original, than that it should acquire a wholly different nature. Those who hold that carcinoma originates from the connective-tissue cor-

puscles have laid upon them a heavy burden of proof; all positive observations brought forward to confirm this theory must be scrutinized most carefully. How easy for a wandering cell, just escaped from the blood-current, and on its passage to the epithelial layer, for example, bearing an original imprint of the epithelioid type, to be delayed and entangled in the connective tissue. Such a corpuscle could easily be mistaken for a connective-tissue corpuscle. Here then, in the connective tissue, under the influence of the unknown force of a morbid nature, it develops into carcinoma. Its further growth and the destruction of the normal tissues are matters of common observation. The cell-growth, according to this theory, is no longer to be viewed as heteroplastic, for the cell was originally of epithelioid character, but merely as a heterotopic display of its original character, and also morbid, since it does not develop epithelium, normal either in its anatomical or its functional characteristics. With those who hold that carcinomatous growths are produced by the continuous multiplication of pre-existing epithelium, the theory here proposed is in entire accord. It adds, however, very material assistance by extending the field for the operation of this law. No one, I think, contends that a carcinomatous growth is produced or can be produced by the multiplication by cell-division from, for example, the normal cells of the acini of the mammary gland. There is need of help for its production by the method of development just suggested, from the wandering cells found in the connective tissue.

With those, also, who teach that the epithelial cells wander from their normal position into the connective tissue and there develop, this theory is again in accord. But the wandering *from* the epithelial or glandular tissue must not be mistaken for the reversal of this process, viz., wandering *to* the tissue. This theory would especially confirm the possibility of the epithelial cells leaving their bed and wandering into the connective tissue; and I believe this occurrence does as as certainly take place as that the corpuscular elements leave the blood and pass to the epithelial or glandular organs to become developed into cells of these organs, and also that these wandering corpuscles had originally an epithelioid type impressed upon them, and do not acquire it by infection or contact with epithelial tissue.

In regard to the theories of spermatic influence, of catalysis, and of epithelial infection, they are exceedingly vague terms, and should not be invoked to explain any process of development, so long at least as our present theories of cell origin and growth are held.

As to the cells or corpuscular elements which crowd the periphery of the carcinomatous growth, this theory holds two views of their origin and nature. First, they are not all to be regarded as wandering epithelioid cells, preparing to develop into carcinoma; unquestionably, many of them are true wandering connective-tissue corpuscles, increased in numbers through the irritative action of the morbid growth, but others are white blood cells, not of epithelioid type, and others are lymph corpuscles. Secondly, many of the wandering connective cells develop finally into the connective-tissue stroma which forms the alveolar walls within which the epithelioid cells of the new growth are contained; other portions of the alveolar walls are not solely of new formation, but are made up of the pre-existing connective tissue, perhaps rendered hyperplastic by the developing morbid growth. The extensions and metastatic formations of carcinoma are produced by the lymph- and blood-vessels taking up the elements of the new growth and transporting them along their respective currents until they lodge. However, not all secondary formations, and especially not in those cases where extensive outbursts of carcinomatous production take place, for example where the whole skin of the trunk becomes affected simultaneously, are to be regarded, according to this theory, as of true metastatic or embolic origin. This theory views as possible an epithelial surcharge of the blood with potential epithelioid germs, which are capable of development in many centres simultaneously or in more or less rapid succession. The question of the epithelial infection of the endothelial lining of the lymph or bloodvessels, according to this theory, becomes an almost indifferent one, except so far as observations on this occurrence bear on the question of the supposed transformation of endothelial, and therefore connective-tissue cells into epithelioid tissue. A wandering epithelial cell, starting to develop during its passage through a vascular wall, would closely simulate the appearance of an endothelial transformation into carcinoma.

When carcinoma develops in such organs as the liver, made up so completely of epithelial tissue, at first sight it may seem difficult to apply this theory of epithelioid growths, at least so far as regards the share the wandering epithelioid cells have in their production. But at the outset, we must premise that the study of the origin of primary carcinomatous growths finds no more difficult field than their occurrence in the liver; that of secondary or metastatic growths in this and similar organs is much more simple, at least in its

theoretical terms ; probably no better field can be selected for the examination of secondary growths and their origin and development, than the hepatic tissues. Here, in the first place, the connective-tissue parts are well differentiated from the cells of the parenchyma, and we are quite familiar with the beginnings of carcinomatous growths, even before they have reached a size discernible with the naked eye, in the tissue of the portal canals. The question much more difficult of solution is their origin in the hepatic cells themselves ; before the true nature of metastasis was known it was supposed that secondary growths, and by consequence, primary growths, of the liver arose from a direct transformation of the hepatic cell into a carcinomatous cell, which subsequently either infected the adjacent cells or by multiplication of itself developed into a carcinoma nodule. Now, however, it has been shown, and I have verified the observation to my entire satisfaction, that a secondary growth may arise in the hepatic cells by the process of vacuolation; the vacuole formed in the liver cells is filled by one or more corpuscles similar to a lymph- or blood-corpuscle, and from this develops, assisted by many others undergoing a similar process of growth, the carcinomatous growth. The corpuscles found in the vacuole have been regarded as nuclei or cells derived from the primary growth, transported by lymphatic agency to their new seat of growth. By the terms of this theory the contents of the vacuolated cell are potential epithelioid germs, and the process of development is the same for the primary growths as for the secondary. Here, then, in primary growths, unlike those of the mammary gland, where, according to some, the epithelioid cell wanders out from the acini into the connective tissue to develop into carcinoma, in the liver we have the epithelioid cell wandering, not into connective tissue, but into a vacuolated space or a liver cell. The analogy in the one case is similar to that in the other.

It is proper in proposing this theory to attempt a definition of carcinoma which accords with its terms. Instead, then, of defining these growths, as according to Billroth, simply by their resemblance to gland structure, and by the origin of their cells, or, with Rindfleisch, by their histogenetic relationships and the character of the cells, let us attempt to include the views not only of those who believe the cells to be only epithelial in their appearance, but also of those who claim them to be of connective-tissue origin. This is by no means simply a compromise definition, but is an actual harmonization of the appearances claimed to be observed and interpreted according to what is believed to be the only justified view, namely, that the cells are actually epithelial cells morbidly diverted from the normal anatomical and physiological path. The definition adds—what I believe to be one of the chief phenomena of their morbid character—an assertion in respect to their point of development, viz., that *they develop out of place.* While holding most firmly to their epithelial nature and insisting most strongly on their histogenetic relationship to glandular and epithelial tissues, both in respect to their origin and direct descent, as well as their mode of growth, I would point out that carcinomatous tumors are epithelioid tissues growing in a position foreign to their normal one.

To illustrate the meaning of this definition of carcinoma, let us examine the histological arrangement of a very young nodule of an epithelioma. In a case where a nodule not larger than a small pea was removed from the lip I made sections of the whole mass, so that the entire growth was subjected to microscopic examination seriatim from one border directly through the centre, and on through it to the healthy tissue on the opposite border. I was able, therefore, to see the condition of all the normal pre-existing tissues of the part, as well as the character and position of every cell of the morbid growth.

The surface of the lip was, to the naked eye, on examination, unchanged, and the microscopic appearances showed only a slight hyperplasia of the papillæ, and perhaps a smoothing out of these structures by the increase of volume of the lip ; the hyperplasia of the papillary epithelium was evidenced by a brighter carmine coloration, and was limited to the immediate neighborhood of the new growth. Especially was it noted that there was no distortion of the level of the lower layer of epithelial cells, no plunging downwards into the subcutaneous connective tissue ; in fact, as the effect of the slight stretching of the skin, due to the presence of the new growth, the level was more even than usual.

The cells of new formation were found assuming the usual forms and grouping exhibited in epitheliomata growing in this situation. At no part did the new growth approach very near the surface, and it had absolutely no connection with it. The skin, gland, and hair follicles, which, in the lip, usually penetrate deeply into its tissues, showed their cells hyperplastic, as was seen in the lower epithelial strata of the surface, but no connection or transition of growth from gland or hair follicle into morbid growth was found.

The "indifferent" cells, which are constantly present in and around these growths, did not hover around the border of the skin and glands, but were confined to the periphery of the new growth or infiltrated the adjacent deeper tissues; in other words, there was no appearance indicative of a wandering of epithelial cells from their parent tissue into the connective tissue, and their development into, or infection of, the connective-tissue cells.

In examining successive sections taken in regular order from the growth, besides the large rounded (cylindrical) groups or nests, many minute clusters of epithelioid cells were seen; in the first section through one of these clusters one or two cells would appear, in the next section three or four cells were seen placed side by side in each diameter of the group, in the subsequent sections the number of cells decreased and finally disappeared. The smaller, and, therefore, probably, the younger groups of cells, found thus isolated and separated, like all the large groups, from any connection with pre-existing epithelial structures, were seen to be growing by addition of embryonal indifferent cells placed at their periphery and becoming finally part of the group. Cell-division also contributed its share to the growth, but in the younger groups, as compared with the larger, the cells were always less in size.

This observation (made a number of years ago, when I had no clear conception of a carcinoma, and had been taught and believed quite another view from this one) shows positively the occurrence of carcinomatous growths distinct and disconnected from the pre-existing epithelial tissue. It does not show positively that the cells or nuclei with which it commences growth were not wandering elements from the epithelium of the surface. However, whether the elements wander *from* the epithelia or not, does not specially concern us, and if it were true, the fact would so far confirm the statements of this theory and indicate conclusively the lineal descent of the cells of the new growth—and this is the important point. I think, however, the observation, so far as it goes, favors the belief of the deposition of the cells or nuclei from the blood current, and the arrest of them in the connective tissue; they do not reach their normal seat of development, but become epithelioid while situated in the connective tissue. That they grow epithelioid shows, if we believe in cell descent, that they are original and permanently epithelial germs.

It would hardly be fair to cite this observation as the result of the examination of an epithelioma, without stating further evidence of the nature of the growth. Subsequent to the removal, the tumor recurred in the lip, presenting characters microscopically similar to those of epitheliomatous growth, but no examination was made of its nature, and after that I lost sight of the patient. The operation was done by Dr. Wm. Hunt, in the Pennsylvania Hospital.

I think that Billroth's definition is defective in likening such structures to epithelial glands; the only resemblance that they have to gland structure is in the presence of a mass of epithelial-like cells; they entirely lack the arrangement of a gland, even such a gland as the liver, in which the glandular structure is far from evident at a casual glance or even on close study, and they are as unlike simple tubular glands as a dissimilar arrangement of cells can make them. His definition holds good in *deriving* the cells from true epithelia; he does not insist on their *proceeding directly* from epithelia.

Rindfleisch believes that the epithelial cell wanders from its parent tissue and infects the connective-tissue corpuscles, etc., which surround the morbid growth; in other words, proceeds directly from epithelial surface or secreting glandular tissue, and that it depends upon an abnormal growth of the epithelial tissue. I have already shown that other observers decline to accept this opinion, and have also pointed out the liability to error in the observations intended to support it. The characteristic cell, and the alveolar structure, according to which feature it was formerly sought to define carcinoma, are, as we have seen, phenomena insufficient for the distinction, and in comparison with the origin and mode, as well as with the position of the growth, unimportant factors. The cell is essential, the alveoli are accidental conditions, although necessarily and invariably present, and this portion of the growth is usually less abundant in organs where the connective tissue or substance is normally scanty. It is probable also, that the place of development of these epithelioid cells furnishes, or, perhaps, causes, one of the chief clinical symptoms of these growths, namely, malignancy. As we have seen, a true adenoma is a development of epithelial glandular tissue, produced by out-budding of the acini or tubules of the gland, and the new growth is directly continuous with old, although it may not be of such a nature as to develop into a tissue capable of its physiological function. It is not, as in carcinomatous growths, an epithelial cellular formation, taking place in a dissimilar tissue, and wholly disconnected with tissue of origin; hence the low malignancy of the adenoma. It is but fair, therefore, to attribute to this feature of the carcinomatous growth the element of

malignity which it generally possesses in such a conspicuous degree. It is quite unfair to attribute the misplacement of the seat of development of the epithelioid cells to the malignant character of neoplasm; malignancy signifies a hypothetical attribute, about which, as yet, no general agreement has been reached, and is a word which has descended in pathological conceptions from older times, when the prevalent notion of disease was a possession of the devil. In these days of physiological pathology, we regard disease as a modification of healthy action, not as a new kind of action; the question of the force which produces the modified action as yet remains unsolved, but when known, will explain why it is that the epithelioid cell starts to grow, not in the epithelial tissues where it usually develops, but disconnectedly in some tissue or space of another type of organization.

The classification of carcinomata has been made on various bases; according to methods which offer no principle of division; according to the tissue or organ in which the growth is found, for example, mamma, skin, or mucous membrane, etc.; according to their clinical aspects or physical appearances, as hard, soft, ulcerated, vascular, atrophic, or colloid, etc.; finally following the histogenetic method, on which too great stress cannot be placed, we divide all carcinomata into glandular and epithelial, and each of these divisions present subdivisions generally founded on resemblances to the various types of normal tissue, which they simulate with greater or less exactness, or on certain metamorphoses which take place either on the one hand in the epithelioid cells, or on the other hand in the stroma of the growth, as well as sometimes in both of these constituents.

Of the glandular division of carcinomata, we have, 1, scirrhus, or hard; and 2, encephaloid, or medullary. It is important, before passing to the consideration of the various modifications of these forms which have been introduced under this variety of carcinomata, to arrive at a clear distinction between the hard and soft kind, and to know wherein it consists. These names have been applied to these two kinds both from their consistence and from structural peculiarities which they possess. The scirrhus is a hard tumor, and its structural peculiarity consists in a large amount of fibrous stroma and a great firmness of the trabeculæ; in the majority of instances the cells are of small size and not plump and round, and the fluid or juice is of small amount. The same tumor presents a varying degree of firmness at different parts; often hard and soft parts are side by side, and the different degrees of density are, at least sometimes, apparently due to the varying age of the different part of the growth. The older parts are dried, with smaller cells and a greater abundance and firmness of the alveoli. The small-cell infiltration at their periphery is of small amount, and the nuclei of the alveolar connective tissue are inconspicuous, especially so in tumors of slow growth, or in those which are apparently at a standstill. Tumors which are of soft consistency, especially those of the mammæ, are occasionally found to present an abundant stroma; their softness being due to the infiltration of the connective-tissue parts of the morbid growth.

The soft or medullary carcinoma shows in comparison but little connective tissue, and its fibres are delicate and attenuated; the cells are of the largest size produced in these growths, and the fluid is abundant. At the periphery of the growth, and likewise in its interspaces, we find usually very numerous small corpuscular elements. The trabeculæ exhibit numerous and large-sized connective-tissue nuclei, and often spindle-shaped cells. Occasionally growths possessing all these characteristics of the cells and stroma are met with of great density, equalling that of the scirrhus, but which, from the histological appearances and clinical phenomena, must be described as belonging to the medullary variety. Recently I met with such an instance; the specimen was quite as firm as a cartilaginous tumor, and was supposed to be of this nature. The great density was due to two causes, viz., the absence of juice, and the very close packing of the cells in the alveolar spaces; two causes which go together and seem to be productive of each other. The cells, however, were of the very largest size.

Judged from the standpoint of physiological pathology, it is difficult to clearly perceive any essential distinction in the nature of these two varieties, which cannot be accounted for by the rate of growth and the activity of the cell-deposit and multiplication. The two varieties are found to interchange their characteristics; the large-celled (medullary) variety may be a firm growth, and vice versa. The firm growth, after extirpation, frequently returns as a soft tumor, and with successive excisions and reproductions it becomes softer; the metastatic formations from a primary scirrhus may present the typical medullary characters. It is not just to argue that a tumor which for a long time has been hard and subsequently becomes soft, and which presents, on examination after removal, the characters of a medullary growth, is an instance of the transformation of one variety into the other, because we have no conclusive proof of its nature from a microscopic ex-

amination; but certainly clinical evidences favor a belief in its frequent occurrence. Therefore, it cannot be held that there is any essential difference in these two varieties; the two names, however, are often a convenience.

The firmness of the stroma of the carcinomatous growth is due to the reactive changes in the connective tissue; in the presence of the morbidly growing epithelioid cells this tissue takes on what may be regarded as a slow interstitial inflammation. In some instances this tissue develops numerous fibres with a strong tendency to retraction; in others the connective-tissue hyperplasia is of a much less degree, and its retraction is largely overcome by the abundant fluid and the cellular elements. This occurrence is paralleled in many instances by the behavior of fibrous and connective tissues of not dissimilar character, but under other circumstances.

The atrophic condition which sometimes supervenes, especially to be seen in growths of this character in the female breast, is due to an exaggerated development of the interstitial fibrous tissue (stroma). It should be mentioned, however, that this process of so-called cicatrization of carcinoma is regarded by many as a *primary* fatty degeneration of the epithelioid cells of the neoplasm and the consequent falling in or collapse of the alveoli. Although these cells are typified by a vitiated vitality, and therefore prone to decay, complete fatty degeneration, and the cessation of the new development, is so unlike the action of the vast majority of these tumors that it is difficult to believe that the initial step of the atrophic process is in the epithelioid cell; besides, this supposition does not account for the great proportional increase of the fibrous stroma.

A subdivision of the soft carcinoma is the telangiectatic, called also fungus hæmatodes. Blood cysts, as well as other cysts, are not an infrequent occurrence in the medullary growths, due to interstitial hemorrhages or softening, but in addition to this comparatively common occurrence, there exists a rare variety in which from the beginning of the new growth an unusual preponderance of vascular new formation takes place by the side of the epithelioid formation. The common seat of such a growth is in the highly vascular secreting glands, for example, the testicle or ovary, although the liver, more highly vascular than any, is not liable to be thus affected.

Melanosis occurs in the encephaloid or soft growths, just as in the sarcomata, more frequently than in the harder forms. A sarcomatous carcinoma is also described; it is sometimes called a sarcoma carcinomatodes. The softer the growth, the greater the degree of malignancy, and therewith also the greater the frequency of metastatic formation; the softness and fluidity certainly contribute a large share to the freedom of movement of the cell elements, and to the greater likelihood of these bodies being taken up and transported by the lymph and blood-currents.

Of the metamorphosis of these growths, the colloid is the only one that requires to be spoken of; so far as atrophic scirrhus can be considered a metamorphosis, it has been already alluded to in the process leading to this change; the cystic formations, when they are not produced by local softening and subsequent fluidity, are due to the obstruction of the ducts by the periacinous morbid growth and the retention of the contents of the acini, together with the mucoid or other degenerations of their epithelia, and are therefore retention cysts. In colloid degenerations, spoken of by many as a separate variety, the question arises which of the component tissues undergo change, or contribute the colloid material. At the first glance it would seem to be the blood current pouring out the gluey substance into the alveoli, but for physical reasons this view cannot be maintained. It is a question of tissue change; but is it a degeneration or a growth? Certainly some appearances lead us to conclude that the cells are transformed into this material by actual degeneration, while other appearances point to a failure of the new material which otherwise would form new cells to develop, and that this substance is, immediately on its entrance into the alveolar spaces, transmuted into a colloid substance; whereby we are reminded of growth and production of a new substance.

The second division of carcinomata, the epithelial growths, are subdivided very variously by authors; some dividing them, in correspondence with the two kinds of epithelium, into the squamous or pavement, and the cylindrical, with sub-species of the pavement, such as the lobulated, those with cell-nests, and the tubulated; others speak of them according to the form of the neoplasm, as flat, or infiltrated, or ulcerated; and others regard all forms as similar, and class them all as epitheliomata, at the same time making another class for growths which resemble them in many features but which are less malignant, viz., cancroids. Certainly many of these divisions into species can have but little value, either in their surgical aspect or for convenience of histological study; the two varieties formed in accordance with the two principal kinds of normal epithelium present the advantage of indicating the origin and seat of the new growth, but in other respects no two epitheliomata are thoroughly identical, unless by chance

they grow from identical points of the integumentary or mucous surfaces, and even this fact does not insure a similarity of growth in every instance.

In coming to a definite understanding of what is the essential character of an epithelioma, we at once meet with the same questions as in glandular carcinomata. We no longer hold the peculiarity of the cell or the existence of a stroma as determinative features of the growth; neither a nest nor a pearly globule is an essential part of the structure. Here, likewise, much more than in glandular carcinomata, do we have difficulty in accurately separating the hypertrophies from the morbid growths; in glandular carcinomata it has been pointed out that there are transition forms, with many intermediate steps between a simple glandular hypertrophy and glandular carcinoma. The adenomata represent the tumors which do not belong to either one of these forms. But yet, although less apparent, there is a gradation series between hyperplasia of the epidermis and its papilla and a true epithelioma, and what we are especially concerned about is the determination of the point where and when the boundary line is passed. I cannot find that investigators have arrived at any definite conclusion on this point; that there is a definite demarcation between the hyperplastic and carcinomatous epithelial formation, is believed to be certain; it cannot be that the distinction rests on the quantitative elevation or depression from a certain plane. It cannot be that the difference between a papilloma or warty growth and an epithelioma rests alone on the fact that in the former the connective-tissue papillæ prolong themselves above the normal level, while in the latter the epithelial structures plunge down into the connective tissue. I prefer to seek some more essential characteristic, and I think it can be found in a similar distinction to that pointed out in the glandular carcinomata. In my own studies of this subject, I have found that in its earliest formation the epithelial tumor consists in a development of epithelial cells, separated completely from the epithelium covering the papillæ, and taking place in the connective tissue, and I believe it is from this condition that the epithelioma derives its characteristics. The place of development is, therefore, the essential distinction between an epithelioma and all those forms of epithelial change which are correlated to it. In the later stages, all those changes in the papillæ and epithelium, which result in their striking deviation from their normal level, very constantly take place, and contribute largely to the mass of the tumor, as well as to the successive alterations which find place in it. That many growths which do not develop in this manner have been classed as epitheliomata, and have confused our conceptions of its nature and malignancy, is unquestionably true. That many growths commencing as epithelial prolongations into the connective tissue, and subsequently exhibiting a development of epithelioid cells, disconnected and situated in the subjacent connective tissue, with a corresponding addition or accession to their malignant nature, I believe to be true. The malignancy and carcinomatous character is due, as in glandular carcinomata, to the growth of epithelioid cells away from their normal position.

In contradistinction to this view, it is usually held that the new growth of epithelial tissue takes place by division and multiplication of the cells of deeper layers of this tissue, which causes a prolongation into the connective-tissue substance, or as others hold, by mere apposition to the deeper parts of the epithelium and by transformation of the lymphatic endothelia. These two opinions are respectively those which find place in regard to the development of glandular carcinomata. Whilst unquestionably appearances indicating the occurrence of this mode of growth are to be seen in epitheliomata, and in the later stages it does without doubt take place, yet I believe that the initial step which I have here indicated as forming the essential feature of all varieties of carcinomata has been overlooked or has been disregarded, and its significance misinterpreted. All the other structural peculiarities of epitheliomata—their stroma, their surrounding small-cell infiltration, and the destruction and transformation of the adjacent organs—have a similar meaning here as in the glandular carcinomata, which has already been pointed out. The concentric stratification or nesting of the cells, and the production of pearly globules, are striking peculiarities of the epitheliomatous growth, and show that, in spite of the morbid impress which the cells of the growth acquire, they still retain their affinity to the mother-tissue in connection with which they grow, and from which they derive their origin.]

On the mode of death in cancer.—The fatal issue of this disease is sometimes directly and sometimes only indirectly brought about by it. In a few instances, death is said to have been occasioned by a cancerous cachexia independent of the amount of the morbid material found in the body. Such cases await explanation, which will probably come through the implication of the ganglionic system in the disease, and a general incompetence of other organs than those involved in the cancer to maintain life. An exclusive

taint of the blood in them is mere supposition. As the solid organs waste, the blood becomes scanty, but it contains no appreciable element of cancer. Such patients are distinguished by a feeble yielding to death. Those, on the contrary, who possess a vigorous nervous system, and efficient vegetative organs, endure much cancerous, as they do other disease. In them cancer reproduces itself in great abundance, either externally or internally, and the cause and manner of death are usually sufficiently manifest. The disease makes increasingly rapid local progress until the powers of the system are worn out. The body becomes emaciated while the cancer grows, and by hemorrhage, exuberant growth, and discharge, pain, sleeplessness, and inability to assimilate food, is more and more reduced. Last of all, as the strength finally sinks, the cancer itself may be in great part absorbed, and contribute its substance to prolong the weary life. A marked sallowness is then added to the previous paleness of the countenance, and, fainting or more slowly overcome, the patient dies.

Cancer-patients are always much reduced in strength by any sloughing in the primary or the glandular tumor; and if it be at all extensive, they may not recover from it. Death from this cause, however, is rare.

The modes of death not directly issuing from the cancer vary much. Erysipelas and pyæmia rarely happen, and are yet more rarely fatal; but many die of pneumonia, pleurisy, or great effusions into the serous cavities. There is no canal in the body which may not be obstructed or constricted by cancer; and, if essential to life, the closure of it may be fatal. The alimentary canal thus obstructed in its lower part, or the urethra by vaginal cancer, may respectively be greatly relieved by colotomy and by puncture of the bladder. An obstruction in the higher parts of the intestines is necessarily fatal, being incapable of relief by surgical means; thus, the duodenum has been fatally compressed between enlarged cancerous glands. Some patients die of jaundice, from the obstruction of the ductus communis choledochus; and some from starvation, in whom cancer of the tongue, pharynx, or œsophagus prevents swallowing, and nourishment cannot be conveyed into the system in sufficient quantity by enemata, or by a successful operation of gastrotomy.

Cancer is also fatal by laying open, as well as by obstructing, the canals of the body. The œsophagus thus sometimes communicates with the trachea, and when the patient dies with exhaustion and pneumonia, portions of food are found in the air-passages of a lung. I have known the jejunum to adhere to a cancerous vagina, and, being opened by ulceration, to discharge its liquid contents incessantly into that canal by an incurable and exhaustive diarrhœa. The ulceration of uterine cancer into the bladder or rectum entails consequences which must hasten the fatal issue of the disease. Arteries may be closed, by advancing carcinomatous growths, and limbs mortify in consequence; they may also be ulcerated by the disease, and the patient die of violent hemorrhage. Various mortal changes may take place in organs whose nerves are involved in a cancer distant from the organ itself. Cancer of the nervous centres is generally fatal in the same manner. Death may arrive by the pleura, the air-passages, by any important organ of the body indeed, if involved in this disease. And, finally, the cancer itself may disappear, but only as it is supplanted by an equally fatal growth of tubercle or cancer in some internal organ of the body.

Nature of cancer.—The majority of cancer-patients having been remarkably healthy persons, up to the time of the appearance of the primary tumor, the outbreak of a disease so vigorous and destructive, in the course of a very healthy life, might suggest that it had been introduced from without the body. And in its great power of multiplication cancer does correspond with acknowledged poisons. Smallpox, cowpox, and other infectious and contagious diseases, are capable of being conveyed by a very small, even by an inappreciable, amount of poisonous material; but, when communicated, that material may be multiplied in the infected person a millionfold. But the surmise that cancer is thus interjected is not supported by other known facts. As such, cancer is not communicable. It may, indeed, be transferred from one part to another of the same patient. It may, for instance, be implanted across a serous or other cavity, from a diseased to a previously healthy surface. But amongst the myriads of occasions on which the disease might, if communicable, pass from person to person, no probable transfer of cancer has been observed. Nurses do not become inoculated with it: cancer of the penis is not common enough to have been received in coition: surgeons have been extirpating cancers from the time of Hippocrates, but there is no instance of the disease being communicated to an operator. The experiment of introducing fresh cancer into the tissues of the lower animals, lately repeated with much precision by Dr. J. Burdon Sanderson, has been followed by the dissemination of nodular growths of lymphoid corpuscles in many organs; but these were not distinguishable from those produced by the injection

of other matters than cancer, and the implanted cancer was not in any case adopted by the tissues, so as to share their circulatory system, without which it could not disperse its elements. This is, further, a mode of conveyance against which it is needless to argue in human beings. Moreover, the notion of the origin of cancer in an accidental poison is inconsistent with the facts relating to its repeated occurrence in some families, and with the exemption of others from the disease.

Cancer is no more derived from without as a parasite than as a poison. Its minute structure is now known, and its independent life and multiplication can be otherwise explained. Cancer is no intercalated organism, like a trichina or a hydatid; in, but not of, the body. Up to a certain point its growth is like that of tissue, and there are in it recognizable, however disordered, elements of human structure. The blood nourishes it; feeling and the nerves associate it with the brain. With other diseases, its growing is under conditions which cannot be parasitical for the cancer alone. Thus it sometimes spreads superficially, like phagedæna, healing where it first began; healing and spreading, in fact, at the same time. It follows a certain mode of dissemination, the decision of which lies with natural structure, not with the disease. Or it shares with tumors, which are reputed as innocent, a textural relation to the part producing it, a tendency to local recurrence after operation, and a power of reproduction in other parts, which must cause all to be considered of animalcular nature, if it be admitted of any. To some extent, but that a variable one, its vigor of life is subordinate to certain local and general influences; to the vascularity of its site, to the youth or age of the patient, to pregnancy and lactation, to the coexistent health or disease of the patient.

That cancer is a growth *of* the body, though a perverted and morbid one, is borne out by the analogy of other tumors, and is certain when its minute structure is demonstrated. In every growing cancer there are elements, under the microscope, answering to those which occur in other parts, and still more at earlier periods of the life, of the body. Many of the cells are indistinguishable from those of the liver; and so similar are those of one form of cancer to natural epithelial cells, that the likeness has suggested its name. Nuclei and nucleoli are not exclusively cancerous, nor are the fibres, granules, and corpuscles, the pigment, bone, and oil-globules, the bony growths and scars; all are sufficiently like natural structures of the body to show therein the proof of a like origin. Moreover, continuity of substance, though not an absolute proof of the identification of a cancerous tumor with the organ in which it lies, is proof, so far as our present knowledge reaches. For parasites are never continuous with natural tissues, however closely wedged in amongst them, and even the placenta is separable from the uterus.

Origin of cancer.—As this disease is observed habitually to originate in one place, and to spread in it and from it with some order, a distinction is recognized between the first tumor and those which succeed it, the first being commonly spoken of as the primary, the latter as secondary, cancer. The occurrence of double primary cancers is almost always only apparent. We know indeed nothing of cancer which should entitle us to assert that it may not originate in more places than one; yet as a matter of fact, a sequence can commonly be satisfactorily established. In the instance of scirrhus in both mammæ, the second breast is usually affected from previous disease on the opposite side. Cancer has, on some few occasions, been noticed in both eyes, and the occurrence is not certainly explicable by the proneness of the optic nerves to early infection; but, an interval of months having elapsed between the origins of the double disease, the ordinary sequence was probably preserved, and the secondary tumor occasioned in one of the usual ways, by the diffusion of cancer from the first.

If regard be had to the multitude of tumors which are sometimes found in the body at the close of a case of cancer, and to their indiscriminate occupation of various textures, it appears reasonable to seek some single source for them all. Such a source appears in the blood, which is the only element of the body common to all the diseased organs. But, with the vague statement that cancer is a blood disease, all search for the cause of it would be absolutely stopped. Thus to end the inquiry, when nothing morbid has been demonstrated in the blood, is less reasonable than to observe the order of these growths, and to ascribe the successive tumors to those which precede them. Because the many pustules of smallpox are due to the state of the blood, we do not ignore the previous entrance of a morbid substance into it by inoculation or the breath. That which the first poison is to smallpox, the primary tumor is to diffused cancer. It is the source of all the rest, and the inquiry for the cause of cancer becomes a search for the reason of its first outbreak as a tumor.

The sequence of one tumor and a succession of later ones are so obvious that

patients and even surgeons sometimes appear anxious to assign some blow or sudden injury as the cause of the primary. The impression that cancers do sometimes so originate has even led to the attempt to prove that they are but transformations of ecchymosed blood. No reliance can be placed, however, upon the notion, or its supposed proof. It is true that in rare instances an injury is followed by rapid growth of cancer; but the occurrence is not more frequent than may be accounted for by the accidental concurrence of the injury with an imminent or incipient outburst of cancer. The patients in such cases are young, and the form of cancer the medullary. Such a mode of origin is never suggested for the primary cancer of internal organs, or for any of the multitude of secondary tumors. In the vast majority of cases the first tumor is known to have formed without previous injury of the part, or is found to have already attained an appreciable size when the accidental hurt first calls attention to it. The injured spot is that in which the cancer is apt to originate spontaneously. The sequence of events afterwards is precisely the same, whether there be or be not in the history of the case the coincidence of a blow with the first observation of the disease. On the whole, it may be concluded that the primary disease originates by the same spontaneous power as that by which it afterwards spreads, and evokes the growth of the smaller tumors near it. The earliest and latest observations of cancer are alike in respect to its power and mode of growth. Tissues may be ascertained in an operation to have all the visible and tangible qualities of health, and yet cancer may afterwards form in them; there is, therefore, on the whole, no sufficient reason for the invention of a different mode of origin for the previous tumor.

But while it is asserted that a single sudden injury is not cause enough for a cancer-growth, that disease may originate in a part which has long been subject to mechanical irritation. The proximity of a broken tooth to one spot on the tongue, the habit of carrying a clay pipe on the lip, the long-continued contact of soot with the skin, and the retention of the secretions of the glandulæ odoriferæ beneath a contracted prepuce; these and similar sources of prolonged irritation may so alter the mode of life in a part as to issue in cancer. The form of the cancer so originating is always the epithelial: and in the section on that disease, examples are given of its attacking parts in which simpler morbid processes had long gone on.

It is a question often asked respecting the mode of origin of cancer, whether a tumor of innocent nature can become cancerous. This seems equivalent to the inquiry whether an oak ever changes into an elm. The rarity of the occurrence shows that innocent diseases have no special proneness over the rest of the body to become malignant. They have even been observed to show a less proneness; as when cancer fails to attack an already existing chronic mammary tumor, but forms a separate tumor in another portion of the same breast. There are cases in which cancer arises in an innocent growth, as when melanosis first appears in warts and moles, and epithelioma in ulcers, scars, and chronic fistulæ. Sir B. Brodie also mentions one instance in which he removed a fatty tumor, containing scattered cancerous nodules. Since various new growths may co-exist, there does not seem to be any *à priori* reason why cancer might not first occur in an innocent tumor; but not as a natural issue of it. Some innocent growths in degenerating, may resemble cancer in appearance, and some, as the cartilaginous, fibrous, and colloid, may be to some extent disseminated in the manner of cancer; but they retain their first structure to the end. These are the chief cases in which a change in the nature of a tumor might be supposed to have taken place.

As the search for the cause of cancer sometimes ends in the vague conclusion that it is a blood disease, so an ultimate fact appears to be reached when it is called hereditary. It should rather be styled heritable than hereditary; for, while its occurrence in a parent and some of her offspring shows a disposition to it in both, its more usual failure to appear in any of the offspring proves that the tendency has not descended to them, or that it has been averted.

To some extent an inheritance of cancer may be admitted.

1. Some entire families are exempt from the disease. It has even been stated to be unknown amongst some of the aboriginal races of mankind; but such an assertion is very difficult to substantiate or to deny. I have often made the inquiry of medical men who have lived abroad, and have been informed either that cancer was unknown amongst particular races, or that it was far less common than in this country. 2. In other families it is known to have occurred in more than one individual. It was thus traced by Mr. Sibley, amongst the cancer-patients of the Middlesex Hospital, in one case of every nine; by Mr. Paget in one of every four cases. 3. Particular towns and districts of England are more liable to it than others. Thus 1000 women dying in Kent at the age when cancer is rife include 59 who have died of that disease, while in

Lancashire there will be but 30 cases of it in the same number and circumstances.[1]

But though inheritance undoubtedly sometimes favors the production of cancer, it does the same for other, *e. g.*, for fatty tumors, and to attribute cancer as a rule to that influence is deceptive. Often perhaps women have no cancerous tendency at the time when they are bearing children, and the disease in the parents is both caused and developed after the offspring have become independent of them. In such, and they are probably the majority of cases, there is no cancer to repeat. But the fact of inheritance, though the manner of it is not definable, is obvious enough when mother and daughter are so affected in the same organ, or when, though in different organs, it is by its frequency prominent among the diseases of a family. From the experience of Mr. Paget[2] it appears that the cancer of parent and offspring prevails most in different organs; my own observations,[3] upon fewer cases than his, lead to the opposite result. I have found the cancer of related persons to occur in corresponding organs. Particular instances are so striking as to show that probably both views are correct, and that the apparent discrepancy lies in the error of regarding all cancers as alike in origin. On the one hand is the Middlesex Hospital case of a mother and five of her daughters, all having cancer of the left breast: on the other hand is the unfortunate family mentioned by Broca,[4] in five generations of which sixteen persons, out of twenty-six who lived beyond the age of thirty, died of various cancers. In ten of the sixteen the cancer was in the breast.

There is no one cause for all cancers. Their origin is to be sought in influences acting severally upon each organ, and perhaps upon a single part or texture of the organ in which the primary growth occurs. To some extent also there appears to be a near alliance in cause between the innocent and the malignant tumors of the same organ. A power in the body being allowed, by which overgrowth can take place, then the inducement to that growth may be as various as the organs or tissues which grow. After normal pregnancy, for instance (not to mention growths in other parts depending on that state), the mammæ normally enlarge and secrete milk. But milk will flow upon a mental emotion, communicated through nerves, and upon a direct stimulation of the nipples it may be furnished by a virgin, or even by a man. Equally various may be the excitation of morbid growth. To refer still to the breast: some tumors arise during a morbid uterine reflection, some amidst the depression of nervous control which characterizes the subsidence of the sexual functions, and some from a purely local fault of texture, whether recent or itself a result of prior disease. And the tumor thus evoked may in each case be cancer. The causes of a new growth therefore may be local or even distal, and the resulting disease be perhaps less determined by the cause than by the texture on which the stimulation acts. Certainly many cancers of the breast arise during prolonged leucorrhœa, or uterine irritation, or in those having fibrous tumors of the uterus; some in an organ which had long since suppurated; and some during the nervous depression of grief or of waning function of the organ. That which there is ground to believe of the causes of mammary cancer may be true of other organs also, and especially in the instance of long-continued disease of a mucous membrane, or of an irritation such as soot. As, however, changes of growth and of function are less remarked in other systems than they are in the generative organs of the female, so is the occasion of the outbreak of cancer rarer and less distinct.

Dissemination of cancer.—Some cancers never spread beyond the part in which they first grow; and there is every gradation and much variety in the dissemination of others in the body. As a general rule, the diffusion of those cancers is the rarer, which either have by their position, or by early ulceration acquire, a free outlet for their pervading liquids; whilst the cancers which are pent within organs appear to shed their growing blastema into adjoining healthy tissues, and to set up in them, and furnish means to the circulation for, new and similar growths. The cancer at the orifice of the womb, which, exciting much uterine contraction, discharges copiously, and the soft tumor which projects wholly into the bladder, is constantly soaked in urine, and, sponge-like, is often pressed by the muscular coat of that viscus, may be contrasted in this respect with the compact and deep-seated cancer in the breast. Secondary cancer is formed in seventy-nine per cent. of the latter cases; of the former in not more than twenty-five per cent.

But there are facts which appear inconsistent with this common rule; for there

[1] The Antecedents of Cancer, 1865, pp. 40–49.

[2] "The Inheritance of Cancer," etc. By W. Morrant Baker. St. Bartholomew's Hospital Reports, 1866, vol. ii., Article XIV.

[3] The Antecedents of Cancer, by Charles H. Moore, 1865, p. 15.

[4] Traité des Tumeurs, 1866, p. 151.

are covered cancers, which remain solitary to the end of life, and there are cancers on free surfaces which do become disseminated. The difference which has been stated is nevertheless very decided, and is probably but partly explicable by the mortality of uterine and vesical cancers, before the period of their spreading to other parts of the body.

The cause of this difference in similar cancers is not yet known, but the dissemination of those which do spread is almost always at first traceable and orderly. When the separate tumors have become numerous, the progress of the dispersion is usually too intricate to be followed. The order appears to be determined partly by proximity and partly by the channels of the circulation. Secondary cancer shows none of the preference which characterizes the primary growth in the selection of its site; it does not, for instance, recur in the remaining breast after extirpation of a mammary scirrhus. If later growths thus showed the same habits as the first, they would thereby prove themselves independent of it; but they commonly select a different site from the primary tumor, and run a different course. In fact, the position of secondary tumors is determined by the accident of conveyance.

The primary tumor enlarges itself in the continuous tissues. This explains all the extension of it through an organ or region, whether there be or be not apparently healthy tissues between the principal and the adjoining tumors. When two organs are unnaturally adherent, the cancerous growth of one sometimes passes across the adhesion and becomes implanted in the other organ. Thus I have seen the only cancer in a lung to be a small portion of an out-growing cancerous gland of the posterior mediastinum, and the only infected absorbent in the root of that lung to be one of considerable size, not more than an inch from the implanted cancer.

The mere apposition of an open cancer is enough to convey the disease to a healthy surface. Thus, in the vagina there may be seen one circumscribed cancer, equal in shape and size with a cancerous ulcer against which the healthy vagina has lain in contact. Cancers of the tongue may thus spread to the palate; and Mr. Shaw once saw a case in which cancer had formed in a healthy part of the skin of the chest, against which a pendulous open mammary cancer had been suffered to lie.

The power of thus implanting itself is sometimes outdone by its conveyance to parts with which it is not in contact. Fragments thus escape from the surface of a cancer and sink in the fluid of a serous cavity. A cancer of the liver may, then, have its seeds growing on the peritoneum in the pelvis; or the active progeny of a tumor of the optic nerve may migrate to a distant part of the arachnoid, and adhere to and envelop the sacral nerves and cauda equina.[1] Even the air-tubes may convey cancer, of which fact Dr. Moxon produced an instance at the Pathological Society. From an epithelial cancer of the neck, which opened into the trachea, fragments were disseminated throughout both lungs, and grew there around the terminal bronchial tubes as is usual when they are distributed in a current of blood. The glands in this case were scarcely diseased.

But of all means of conveyance cancer travels most often and most far by the channels of the circulation. When it is repeated in the glands of the part in fourteen out of seventeen cases, there can be no question of its reaching them by the absorbents; and by some pathologists, cancer of the glands is not looked on as secondary, but as a part of the primary growth. Moreover, while there is no retrograde extension of cancer in the lymphatic system, *i. e.*, against the current of the lymph, there is a progress of the disease from near to further glands, which proves a direct transmission. When, however, by obstruction to its course, the current of the lymph is reversed, most extensive disseminations of cancer by this system are traceable in the new direction.[2] The early, the frequent, and the often exclusive infection of the glands is one of the most clearly established facts in the dissemination of cancer, and manifests a decided selection of the lymphatic system, rather than the veins, of the tumor, for the spread of the disease. There are, indeed, rare and remarkable instances in which cancer appears as a secondary deposit in internal organs, while the intervening lymphatic glands connected with the site of the external primary disease remain perfectly healthy. The fact is noticed about once in every forty-three cases of fatal cancer, and is at present inexplicable; it is too rare, however, to throw doubt on the prevailing fact that cancer spreads first by the lymphatics.

When the diseased material has traversed the glands and thoracic duct, and reached the venous system, the next organ in which cancerous deposits might be looked for is the lung; and, as being the earliest tainted, it should exhibit the

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[1] Pathological Transactions, vol. xviii., p. 220.

[2] "An Illustration of Extensive Cancer traceable to dispersion from the primary tumor, as distinguished from its constitutional reproduction." By Charles H. Moore. St. Bartholomew's Hospital Reports, vol. iii., Art. V.

largest and most numerous, as well as the most frequent, secondary deposits. Yet it appears that whilst the absorbent glands were affected in 140 cases out of 173, the lungs, the next in order of the capillary systems, were cancerous only in twenty-two.

Further on in the course of the circulation, there is the greatest irregularity in the distribution of the disease. The serous membranes are much more frequently affected with secondary cancer than the lungs, the spleen and kidney far less commonly than the bones. But above all other organs rises the liver in its liability to secondary cancer. It is attacked in 6 out of 17 instances taken indiscriminately, but in 6 out of 9 cases in which the disease spreads at all beyond the lymphatic glands of the part. Its liability to infection is strikingly brought out by its contrast with the lungs. It receives, like them, both venous and arterial blood, but, unlike them, is rarely fed at first hand by blood from a cancerous organ. The portal blood arrives from organs which are comparatively seldom cancerous; the pulmonary blood from all the other organs of the body, in which the great majority of the primary cancers occur, as well as from the absorbent system. In advanced cases the diseased liver itself should, upon the hypothesis, send cancerous infection to the lungs; yet, on the whole, they are thus diseased but once when the liver is infected thrice. It may be that some special affinity exposes the liver to the secondary disease; for the kidney is attacked with consecutive cancer but twice in 173 cases, and the spleen, though seemingly so intimate an associate of the liver in function, but once.

Still it is sometimes possible to trace the channel by which cancer reaches the liver. It may come by the vena portæ from an infected spleen or stomach, and may be exclusively deposited in one lobe, which alone has the portal branch patent. It may be cancerous through filtration along Glisson's capsule. The artery may perhaps convey cancer to it, as to any other part of the body. And by no means unfrequently it is inundated with the disease by a retrograde current of lymph; the plugged absorbents of the breast, and especially of the left breast, throwing back their morbid contents upon the liver, as well as on the abdominal and mediastinal lymphatics. Whenever cancer is thus distributed in the liver with a stream of blood or lymph, it becomes a most extensive disease. One half or the whole of the organ is studded throughout with small nodules, or destroyed in great patches by masses of cancer. A solitary tumor is rare; the organ seems mostly affected as a whole; for the tumors often grow so thickly in it as to be nowhere an inch apart. Only in the skin is this profusion of separate cancerous tumors equalled.

Clearly as the distribution of cancer in the body can usually be traced, there are a few cases in which a link connecting its distant tumors is wanting, and in which it is necessary to await further evidence which may reconcile such cases with those in which the mechanical transmission of the disease is obvious. A small intermediate deposit may easily be overlooked, although it be the source from which a large secondary growth is derived; and in this may hereafter be found the explanation of such cases, without resorting to the theory of a separate constitutional origin of each of many tumors. At the same time it may be allowed, that, as there are independent systems of organs in the body, all liable to cancer as well as concurrently to innocent tumors, it is possible that primary cancers, no less than such tumors, may arise independently in more than one of them. Thus it is quite consistent with the origin of cancer from local causes that it should arise severally in the tongue and in the skin of the leg; but in making such an allowance the errors are to be avoided of ignoring the distinct causes of primary and secondary cancers, and of ascribing them indiscriminately, any more than the concurrent simpler tumors, to an occult and unreal source in the constitution.

On the affinities of cancer, and its limitation or control by external agencies or other diseases.—The origin and progress of this disease are apparently independent of the functions of the body, and it is subject to irregularities of its own, and even complete intermission of growth.

Speaking generally, we may say that the cancer of the aged is chronic, and that of the young is vigorous and rapid in its growth. Yet this is not universally true; and if it were, the rule could not thence be drawn that the vigor of the disease is measurable by that of the system in which it occurs. Its victims at every age are indeed mostly persons whose previous health has been remarkably good; but the vigor of its growth, as measured by the number and size of the deposits, generally increases instead of diminishing with the exhaustion of the patient. Improvement of the health does not feed, but starves, the disease; the reverse of what would happen if cancer were directly dependent for its vigor upon that of the system.

The results of statistical inquiry into the ages of cancer-patients confirm the conclusion which has just been stated. It appears that, with one exception, cancer bears a greater relative proportion to the number of persons living in the community as age advances. That exception is

the period in which the generative functions cease. The decline of activity in the female sexual organs is marked by a prevalence of cancer in them, far exceeding that observed at earlier or later periods of life. On the whole, therefore, it may be stated that vigor of life excludes cancer, the cessation of activity favors its occurrence.

The same remark is to some extent applicable to the life of the affected organ, as to that of the system in which cancer originates. The disease does not spring out of the vigor of the part. Cancer does not choose, or grow most in, the organ which is the best supplied with blood; the bones are at least as prone to cancer as the brain. And if vigor of life be measured by the elementary changes and activity of an organ, the stomach should be far more often cancerous than the skin; and pregnancy and lactation should be the occasions for cancer-growth in the breast and uterus. As a general rule, the disease does not originate in those organs during the active performance of their functions. Dr. West ascertained that in 8 out of 109 women the first symptoms of uterine cancer appeared immediately after parturition.[1] This fact has the same import as the observation, that the womb is most liable to cancer in the decade of life during which its function is ceasing, viz., from forty to fifty. Activity precludes cancer; subsidence of function favors it. The facts observed in the breast are not inconsistent with this conclusion, though they do not so plainly demonstrate it. There is the same excess in the liability to cancer of the breast from forty to fifty years of age, as is the case with the uterus, but it is not so manifest as in the uterus, that cancer makes its appearance in the former organ just at the time when its temporary function is subsiding. The breast does not become cancerous so especially on the cessation of suckling, as does the uterus at the end of pregnancy. During its functional activity, the mamma is very rarely affected. I have once met with a case in which, during pregnancy, a scirrhous tumor was first observed in the breast; and Mr. Paget mentions one instance of scirrhus being first noticed in the mamma during suckling: this patient was dead seven months afterwards.

When pregnancy or lactation supervenes upon cancer already existing in the appropriate organs, the effects are not uniform. In the breast the cancer may be so placed as to interfere with lactation, as when it involves the nipple and stops the outflow of the milk; or it may, if the breast have been removed, return at the time of suckling, and increase together with a copious and widely-spread milk-like secretion from the whole mammary region. Thus the local activity and the increase of the vascularity are sometimes accompanied by a rapid extension of the malignant disease. At other times the tumor appears unaltered by the local changes. The increase of cancer in the uterus during pregnancy is usually far from commensurate with the growth of the womb itself, and its rate does not much, if at all, exceed that of a similar cancer in an unimpregnated uterus. The breast is not uniformly affected by uterine gestation. Mammary scirrhus sometimes grows slowly, or not at all, throughout the period of pregnancy; in other cases, rapid extension of the tumor appears to be occasioned by the accident of pregnancy, and by the subsequent increase of the vascularity of the breast. There is thus some difference in the liability of the breast and the uterus to this disease. Cancer of the breast has its course and its interruptions independently of the normal activity of the reproductive organs; cancer in the uterus appears to be kept off by pregnancy.

The relation of cancer to foregone activity of the uterus is strikingly shown in the results of Mr. Sibley's statistical investigations already alluded to, and it accords with the conclusion stated with regard to the predisposing conditions of the disease. Neither virginity, barrenness, nor moderate fecundity favors the occurrence of cancer in that organ; the disease is most frequent in the most prolific. The average number of children by each marriage being taken as four, the families of women afterwards attacked by cancer of the uterus are found to be considerably in excess of that average, being 5.2. Similar fecundity happens in phthisical mothers.

Little as cancer is influenced by the natural actions, it is almost as independent of most of the diseases of the body. The existence of Bright's disease of the kidney does not prevent the occurrence or alter the course of cancer; does not even prevent the withering and complete cicatrizing of the primary disease. Opium-eating is no safeguard against it, no means of altering its progress. I removed the breast of a lady of forty-six, in which a firm cancer had formed and rapidly grown, although she was in the habit of taking never less than nine grains of opium daily. Cancer may co-exist with gout, with diabetes, with extensive skin-disease, with syphilis, caries of the spine, or fatty or hob-nailed liver. Exanthematous fevers are almost unknown in our cancer-wards. The effect of erysipelas upon some cancers is very remarkable. Every trace of the disease may be removed

[1] Diseases of Women, part i., p. 363.

as erysipelas sweeps over a cancerous ulcer, and perfectly healthy granulation and cicatrization supervene, but in a few days or weeks, at most, the original character of the ulcer reappears. Precisely the same event happens from hospital gangrene. An ulcerated cancer thus attacked seemed to melt away in soft pulpy shreds, and with a most fetid discharge. Soft and apparently healthy tissues remained, and partial cicatrization took place. First at one edge, however, and in a month afterwards over the whole sore, the character of cancer reappeared. Certain diseases seem to be very rarely associated with cancer, if not to preclude it. Wherever in a family apoplexy and heart-disease are usual causes of death, cancer is absent or rare. Mr. Sibley remarks the rarity of organic affections of the heart amongst the numerous cancer-patients whom he examined after death in the Middlesex Hospital. Tubercle appears to be incompatible with cancer, for albeit traces of old tuberculous disease are remarkably common in the bodies of persons dying of cancer, and in 34 per cent. of them phthisis exists in the family; the two diseases are never found in active growth together in the same person. Such cases have been described, but they will not bear microscopic examination; the apparent tubercle is really cancer. When active tubercle does exist in the body of a cancer-patient, it has, as it were, supplanted the latter disease, which may wither, and even cicatrize, as the patient is rapidly dying of phthisis. Perhaps the most common concurrent affection with cancer is some form of innocent tumor, as warts and small nævi, and fibrous tumors of the uterus in cases of mammary scirrhus. In this concurrence, and in resemblance both of cause and progress, the most obvious alliance of cancer is with tumors.

Treatment of cancer.—From the foregoing account the writer concludes that it is an error to regard cancer as either constitutional in origin, or as subject to constitutional rule. Having seen occasion, in his own experience of the disease, to alter opinions expressed in the former edition of this essay, he published them, so far as they were formed at that time, in The Antecedents of Cancer. The additional facts and arguments in the present essay appear confirmatory of the views last formed, with which, moreover, the results of the Transactions of the Pathological Society of London appear to coincide. The question involved is not mere theory, it seriously affects practice, and leads to most opposite advice being given by different surgeons. On the one side are those who extirpate cancer at the earliest possible moment, lest the local disease should spread into a general one; and on the other side are some whose counsel is against all operation; and others, who deliberately remove, for example, but half of a breast affected with cancer, desiring that the disease may return. This last astounding practice is the logical result of the notion that cancer is primarily in the blood, and it proceeds upon the vicious hope that, by leaving a part of an organ which has shown itself prone to the disease, the material conjectured to be still circulating may continue to be attracted to an external organ.

The subject of the treatment of cancers involves the consideration of the management of the general health; the remedies suitable for the various states of the external disease; and the special question as to the propriety of extirpating the primary tumor, with the modes of accomplishing it.

General treatment of cancer.—No remedy is at present known to have a specific power of eradicating cancer, of neutralizing its taint, or of altering the nature of its growth. Scarcely more, in our present ignorance of the causes from which it springs, are we in a position to rely with confidence on any means for obviating its outbreak. When an exciting cause is recognized, it should of course be removed, and I have found tumors in a mamma suspected to be cancerous, to disappear on the relief of long-continued uterine ailment—a fact which suggested attention to such symptoms, by way of precaution against mammary disease.

From the study of the influences which appear to control established cancer, it is evident that the greatest benefit at present obtainable from medical treatment is that which is likely to arise from improving the general health. As that fails, the disease advances: with its improvement the cancer-growth is stayed. And the result of such treatment is sometimes so striking, that, in combination with suitable measures for the local management of the tumor, a considerable amelioration of the patient's condition and a prolongation of life may not rarely be looked for. Those methods of treatment which exhaust the bodily strength must accordingly be abandoned; the mind should be relieved as much as possible from sources of anxiety, and should be calmed and encouraged; nutritive food with suitable stimulants should be administered, and such medicinal remedies prescribed as appear best suited to exalt the constitutional powers. Arsenic with some practitioners, iodine with others, the vegetable tonics and bitters, alkalies and opiates, with others, find favor according as they effect this purpose of improving the general health of the patient. In com-

mon with many other surgeons, both of the present and the last century, I have found advantage to be derived from the use of iron; but it is more particularly when united with chlorine that it has appeared to me to be beneficial in cancer. This observation has led me to employ more commonly than any other remedies both iron, morphia, zinc, and potash in this combination. That chlorine is invariably useful I neither could nor need assert, since the conditions which make up general health vary too much in different persons to be all subject to one remedy; and it is not my wish to claim for chlorine, any more than for iron or other medicines, a specific control over cancer. It has, however, occurred to me not unfrequently to inquire whether the marked preference which secondary cancer exhibits for the liver, and the decided action of chlorine upon that organ, may not concur in some measure to explain the benefit derived from the employment of small quantities of that remedy in cancer.

The *diet* of cancer patients should be ample and nutritious. Whether nourishment should be supplied in the form of milk-diet, should include animal food, or be exclusively composed of vegetables, are questions settled by the failure of all to cure an existing cancer. Those surgeons who have prescribed only vegetables or a milk-diet, have spoken highly of the effects in retarding the return of the disease after operation; but it must be observed that an extensive trial is necessary to establish any statement as a fact in respect to a disease so variable in its natural course, and that there is no evidence in the nature of cancer, or in the result of many prolonged cases in which the diet was not so restricted, to show that animal food is prejudicial. The plan of nearly starving a cancer patient, with a view of delaying the return of his disease, has been just as highly spoken of. I have not tried this plan, or seen it tried, and am disposed to think that a disease possessing so great and exhaustive a power of growth with a feeble vital stability, rather necessitates an ample supply of nourishment for the subject of it.

Local treatment of cancer.—Considerable skill is required in adapting the local applications to the varying conditions of the disease. In its occult stage it should be supported, not compressed, should be shielded from changes of temperature, and carefully guarded from injury. When not thus cared for, it is apt to be attacked with unusual pain, which indeed often follows the necessary manipulations of the surgeon in examining a cancerous tumor. A layer of cotton wool, fastened on with a kerchief or bandage, best fulfils all these indications: the further directions of the surgeon as to securing rest for the tumor vary with the organ or neighborhood in which it is situated. Of medicated applications those should be avoided which excoriate the surface, and those which contain mercury; but the various other discutients may be used, and may, if desired, be combined with sedatives. Iodine, opium, and especially lead, appear to be the most effective in reducing the adventitious swelling and retarding the growth of the tumor. Equal parts of the iodide of lead and opium, with an astringent of iron, suspended in glycerine paste, form a convenient ointment. It should be laid daily on the swelling, and left there in order to soak into and continually moisten the surface. A leathern or amadou plaster will be found a very comfortable application, as it may be retained on the part for weeks at a time, and it withdraws the tumor for that interval from the close and anxious scrutiny of the patient. It may be spread with opium or other emplastra according to the indication of the moment; but it is by no means certain that the reduction in the size of a cancerous tumor and the softening of infiltrated skin, which often take place beneath a plaster, are not due to the gentle irritation which it causes, and the protection it affords, as much as to any medicinal properties of the drug which it happens to contain.

When sloughing of the tumor, or a portion of it, occurs, the appliances referred to in the article GANGRENE must be used. A bread poultice will commonly be found the most soothing application in the great pain which often attends this process, whilst the balsam of Peru or powdered charcoal, laid on beneath the poultice, corrects the offensive fœtor, and favors the separation of the slough. The painful, precipitous and rugged ulcers, which form in the centre of a mass of cancer, are often most easy, and kept most free from offensive odor by a weak solution of the chloride of zinc in the sedative solution of opium. They should be often washed out with a stream of tepid water having in solution a little chlorate of potash. Weak lotions of carbolic or sulphurous, of citric or acetic acids, of conium and opium, and of the diacetate of lead in combination with one or both of these vegetable sedatives, may also be alternatively employed. A solution of powdered opium itself sometimes affords more effectual relief in such cases than any of the preparations that are made from it. Tender ulcers are best treated with an ointment, spread on cotton wool, than which there is none better than one made from half a pound of fresh bruised leaves of stramonium, in four pounds of lard,

and strained when the leaves have become friable under exposure to a mild heat.

For open cancers presenting little activity on their free surface, sores which are less excavated by ulceration than tuberous from the outgrowing of the subjacent cancer-material, and which appear as ordinary carcinomatous masses merely uncovered by skin, cotton-wool is sometimes treatment enough, there being no indication but that of supplying a kind of cleanly sponge to receive the thin discharge which oozes forth. The oxide of zinc, the trisnitrate of bismuth, and similar innocuous substances may be applied in the form of powder or of ointment.

The œdema of a limb, produced by cancer in some higher part, is often a very troublesome symptom to the patient. It may be treated by fomentations, by steam, or by the application of vinegar. In the intervals of such treatment the greatest relief will be afforded by soft bandages; by firmly swathing the limb, for instance, in a flannel roller. The pain in the arm complained of by patients suffering from cancer of the axillary glands is often too great to be accounted for by the œdematous tension of the limb, and is probably due to the invasion of the principal nerves by the growth. In the lower extremity, where the inguinal glands are superficial and the nerves are deeply seated, the œdema which results from the cancerous infiltration of the former is a far less painful symptom than in the arm.

As the disease advances, the sufferer should be prepared to see without alarm moderate hemorrhages from the surface as it is dressed, and may be supplied with a fresh infusion of matico, or with a solution of the perchloride of iron, to arrest them. If ulceration spread into the neighborhood of large vessels, the surgeon must himself be on his guard, and should make the patient aware of the possible occurrence of hemorrhage, which, under such circumstances, may be rapidly fatal. (See HEMORRHAGE.)

The *treatment adapted for the primary tumor* in cases of cancer is a question of great moment and difficulty, and divides the opinions of surgeons. Practitioners who are sufficiently agreed in respect to the constitutional treatment, who agree also in acknowledging that there are cases which resist all remedies, and for which no plan of treatment is to be held answerable, who are further at one in regarding cancer as capable, on the whole, of being modified in its course and severity, of being lengthened out in its duration and lessened in respect to suffering, by treatment, differ totally in regard to the management of the primary tumor.

The question relates to the propriety or impropriety of removing that tumor. In respect to an innocent growth, the right proceeding is sufficiently plain. If the system be healthy, the tumor growing or inconvenient, and the circumstances of season, air, and place suitable, an innocent tumor may be safely and finally extirpated. But when the tumor is malignant, excision in the very large majority of cases is not a final remedy. The disease returns in the unhealed wound, or in the scar, or in the glands; or, should those parts remain healthy, the internal organs and distant structures of the body become cancerous, and sooner or later, after all, the disease is fatal. As, moreover, some few persons actually die of the operation, great mortification and regret are naturally excited by its failure, and the propriety of repeating it in other cases is denied. Measures are adopted as alternatives of the operation, which are believed to be calculated to repress the growth of the disease, but by practitioners of this opinion the primary tumor, with whatever power of spreading infection it may possess, is left attached to the body. Notwithstanding occasional most painful failures, the following considerations appear in certain cases to establish the propriety of extirpating the primary tumor.

The operation in cancer being most frequently performed on scirrhus of the female breast, the following remarks apply to it, unless distinct reference to other cases be made.

The grounds on which an operation in cancer may be performed should be distinctly understood. They are, 1st, the hope of entirely and finally eradicating the disease; 2d, that of obtaining some interval of health and useful life in its course; 3d, that of, on the whole, lengthening life; 4th, that of diminishing the total amount of suffering.

1. The first of these reasons may sometimes, but rarely, sway the mind of surgeon or patient in deciding upon an operation. The evidence of thoroughly competent surgeons is to the effect that unquestionable cancer of the breast, and less rarely of the lip, has been removed by operation, and through a life of many years has never reappeared. Practically, however, on account of its rarity, this consideration can have but little influence in the decision of the question.

2. The hope of temporarily renewing the health and usefulness of the patient is the chief, though not the only, ground for recommending an operation. Regarded by itself, it cannot but be esteemed as a very great benefit, and from the point of view of the patient may seem and be of infinite importance. What the duration of that interval may be is commonly too uncertain to be predicted,

except in cases which ought not to be operated on at all. Upon an average of properly selected cases it may be said to extend to about twenty-four months; the majority of patients having some recurrence of the disease in the first year, whilst the others remain free from it for a considerably longer period. Four years is not an uncommon gain. The longest intervals which elapse between the time of extirpating a scirrhous breast and the recurrence of the disease occur in cases in which the operation is performed within a few weeks after the discovery of the disease. Ten or twelve, even fifteen years of health have sometimes intervened, when patient and surgeon have both been thus prompt to detect the nature of the tumor and to decide upon its removal.

3. Though we are necessarily ignorant of what would have been the duration of life if the disease had been left to run its course, yet life may be confidently assumed to be lengthened when the early effect of removing the primary disease is a return of both a feeling and an appearance of general health which did not exist before the operation. The only other mode of determining the influence of an operation upon the duration of life is that of contrasting the average duration of life with and without it. No observations exist by which this contrast could be fairly drawn. On the one hand, the majority of the cases selected for operation are such as present the least probability of early death; these give too favorable a view of the operation: on the other hand, the speedy mortality of the operation itself, though rightly enough to be set in the balance against the performance of it, yet occasionally vitiates the observation of its effect upon the progress of the disease. With these restrictions, which, however, in some degree compensate one another, the result of the operation, as observed in the Middlesex Hospital, is decidedly favorable to its performance. It lengthens life in some cases hastening to a fatal issue, and can seldom be accused of really shortening it. The average duration of life in seventy-eight cases of breast-cancer not operated on was 32.25 months, while in fifty-seven patients from whom the primary tumor was removed life reached an average of 53.2 months. Sixty operations were done on these fifty-seven patients, and the average includes three deaths, or 5 per cent., which resulted from the operation.[1] Since the operation has been done in more advanced disease, and the risk increased by more freely opening the axilla, worse cases have enjoyed an extension of health over three and four years, but the mortality has doubled. In one year the deaths amounted to 3 in 12.

4. The argument in favor of an operation which is looked for in the resulting diminution of suffering may be in some instances difficult to substantiate. The operation sometimes *appears* to excite the local disease to activity which it did not previously exhibit; but in properly selected cases and after an adequate operation the suffering is usually far less than it could have been without one. The disease is transferred to other parts, and the patient is spared the distressing consequences of sloughing, ulcer, and discharge which arise from the external situation of the disease. It is no slight alleviation of the total suffering to be relieved of one, and commonly the worst, of the tumors. But further, when an active disease returns *in loco* after a long interval of time, the rate of its growth is sometimes much reduced, and the life is unexpectedly protracted. And if the course of the recurrent disease be but ordinary, the suffering is no greater than it might have been if the tumor had been left to itself. There are cases of pain as great, and growth as exuberant, when the disease has pursued its natural course, without surgical interruption, as when it recurs after operation. At the post-mortem examination of a case of cancer of the breast, it is often impossible to predicate whether there has or has not been an operation in the course of the disease. The appearances on the chest are alike, and there is no appreciable difference in the mode or extent of the cancerous depositions within the body. It seems clear, therefore, on the whole, that the patient who escapes the recurrence in the external part is greatly better for the extirpation of the primary disease, while she in whom it returns has had her interval of health, and is eventually no worse for the operation.

Upon the four grounds just stated, the majority of cases of cancer are not adapted for operation. Certain conditions of the patient or of the disease suffice to preclude it. Those of the patient are such as would interfere with any operation. No operation should be performed if there be reason to suspect a deposition of cancer in an internal organ; if there be albuminuria, or indication of organic disease, or of a state of the constitution which would render any operation improper. A permanent increase in the rapidity of the pulse, which cannot be accounted for by manifest activity of growth or by degeneration in the tumor, or as a family peculiarity, is a strong proof that the disease is already constitutional, and weighs much against operating, except for the comfort of the patient. Unfavorable states of the disease chiefly arise from the most deplora-

[1] Sibley, loc. cit., pp. 123, 126.

ble delay in attending to it. They must be described more at large.

1. A diffused scirrhus, one which widely infiltrates the breast-tissue, must not be operated on. The knife could only be carried through diseased textures, and the wound would not heal. Œdema, which does not disappear during rest and under suitable treatment, is decisive against an operation.

2. The existence of cancerous tubercles in the skin over a mammary tumor is a sufficient reason for avoiding an operation. That contamination of the skin with cancer which is shown by its increased thickness, its wide adhesion over the tumor, the enlargement of its pores, and the difficulty of pinching it up, as can be done with the soft loose skin of the opposite mamma, is decisive against the operation. Though the incisions were made in healthy structures, outside all the thickened part, and though the wound might heal, yet the disease would rather speedily return in and near the scar.

3. By the time the glands are extensively diseased, when *e. g.*, those above the clavicle are enlarged, the primary cancer is likely to be too widely spread for more than a short relief from the removal of it.

4. An adhesion of the tumor to the pectoral muscle weighs much against the operation, but if the disease be small and deeply seated, does not forbid it.

5. Rapid growth and medullary nature offer hope of benefit from the operation only if the latter be early performed, and in clearly healthy parts.

6. No case should be operated on if there be more than one tumor in the body. The co-existence of cancers of both breasts, for instance, or in two limbs, though both removable, renders an operation on one or on both improper. In some rare and chronic cases there may appear reason to depart from this general rule, and to remove one or even two incommodious tumors.

7. Cancers beneath the scalp should not be interfered with; they are rarely or never single, and they often extend through the skull. Those which spring from the bones of the face, and protrude into its cavities, are but rarely adapted for operation. In their early stages they will and may be removed in the hope that they may prove to be of innocent nature; but in their advance toward the surface, where they become clearly recognizable, they often lose the character which alone permits of their being extirpated, namely, that their boundaries be plainly limited. Tumors of this nature which widely expand the ethmoid cells, or the maxillary sinus, which raise the nasal bones, or which cause swelling above the zygoma or behind the ramus of the jaw, as well as those which are connected with the base of the skull, should not be touched. Cancers of the eye may be freely operated on, if still limited within the orbit. Scirrhus in that organ is slow in returning after an operation, and is asserted by Mackenzie, who described it, sometimes not to recur. Even if the disease be of the medullary or melanotic form, prolonged relief may be looked for from an adequate operation. As the disease involves the optic nerve at an early period, if it do not even sometimes originate there, it is necessary to divide it far back and to apply the chloride of zinc to the wound at the close of the operation. Large soft cancers in the neck can rarely be removed. Their appearance of mobility is often deceptive, and they may possess intimate adhesions to the vertebræ and other deep structures. Comparatively less benefit, probably, attends operations for cancer in young subjects.

The following cases may be selected for operation, with the hope of benefit:—

1. When the disease is a single tumor, clearly distinguishable, not diffused, and whether in the nipple, on the surface, or in the substance of the breast.

2. When the nipple alone, or some portion of skin, is drawn in towards the subjacent tumor. In either case, the superficial part not being widely infected but simply dimpled, the breast may be removed.

3. The ulceration of a cancerous tumor does not preclude the operation, if in other respects the case be fitted for it.

4. If the glands be diseased to an extent which does not interfere with their removal, the primary disease may be extirpated. It is my own practice to remove the glands, inasmuch as the disease, when established in them, is as independent and as capable of multiplication as an equal quantity of the original tumor; and it is advisable always to examine them, even when apparently healthy, since they are not unfrequently upon exposure found to be cancerous.

5. A limb may be amputated for cancer, although the glands show some hardening or doubtful enlargement. This rule applies both to the medullary and epithelial disease. A year's relief may also sometimes be gained by removing a superficial epithelioma, as of the heel, although the absorbents are already much affected. The pain attending the latter stages of the disease in the testis renders it advisable to castrate, so long as the cord is healthy in the part to be divided.

6. It might be supposed that a marked hereditary tendency would render cancer rapidly fatal, and entirely preclude any operation. Yet in the family already referred to, of which six members were the

subjects of the disease in the left breast, one sister suffered amputation of the breast on account of it in 1845, and another in 1846. Both patients remained well until in each of them a recent recurrence of the disease rendered necessary a repetition of the operation in 1856. Both also were alive and well in 1863. It is worthy of remark, that the breast was removed from one of these sisters by Mr. Arnott, in a month after the first discovery of the scirrhus, and when it was no larger than the end of the thumb.

7. A recurrent cancer may be removed under the same restrictions as apply to a first operation.

8. Under circumstances of age, or such mere infirmity as will not render the operation fatal, it may sometimes be right to remove an active cancer, which is inevitably mortal; when an innocent tumor, being a mere inconvenience, would be left to die with the patient. Every such case must be decided on its own grounds, according to the judgment of the surgeon and the choice of the patient.

In this advice to perform operations for cancer, the utmost attention is intended to the thorough extirpation of the disease. Much of the erroneous fear of operations in cancer, and mistakes as to its original nature, arise from the unhappy results of incomplete operations. In a paper on The Influence of Inadequate Operations on the Theory of Cancer, in the fiftieth volume of the Medico-Chirurgical Transactions, the writer has endeavored to show to how large an extent the recurrence of cancer is due to the incompleteness of surgical operations, and that even after many years a fragment left in an operation may grow to another tumor. It is hence advisable to study carefully beforehand the extent of the disease in the skin and other textures, and not only to cut wide of the tumor, but with it to remove the whole organ or part in which it is seated, such as breast, eye, testis, scar, bone. In limbs, as a general rule, amputation is preferable to a limited excision. Whenever the incisions are necessarily carried through parts in rather close proximity to the disease (and the healthiness of the cleanest looking wound may be suspected), such parts may be touched with the solid chloride of zinc, and undiluted sulphurous acid, or the chloride of zinc lotion, should be very freely sponged over the surface before closing the wound. Mr. DeMorgan in his pamphlet on this subject recommends the lotion to be made of a strength of thirty or forty grains to the ounce. In certain situations, as in the rodent cancer of the face, or in recurrent medullary in the orbit, it is impossible to remove the whole disease with the knife. A complete extirpation may nevertheless be secured by following up the excision with the actual cautery, and with the caustic paste of the chloride of zinc. When laid on the fresh wound, the zinc forms a dry slough with the superficial textures, which in due time comes away.

The operation should be done at the earliest possible period. All delay is to be avoided, except that which may be required for the improvement of the general state of the patient. There are surgeons who reserve the operation almost only for those few and rare cases in which the disease long remains a local affection, and becomes a source of much suffering only in its later stages. There are others who, concurring in the propriety of an operation at some time, but observing that a temporary cessation of growth sometimes intervenes between the first outburst and final ulceration of the primary growth, recommend that the operation should be postponed until that interval arrives. But if it be a just view of cancer, that from the primary tumor there is constantly emanating a material, by means of which, both before and during this uncertain interval, contamination of the rest of the frame is going on, the principle must be erroneous which leaves such a tumor connected with the frame. No means but extirpation can be trusted to prevent that mischief.

Again, the practice of leaving the primary tumor, in the hope of removing it with better effect at a later period of the disease, is virtually, in the great majority of cases, a final decision against the operation. Adhesions take place, the cancer spreads, and the opportunity of removing it never arrives.

To adopt the principle of delay is to ignore those facts already mentioned, which show how long-continued may be a patient's freedom from the disease, if it be early removed, and the lessening of its activity, should it recur.

Such considerations deter me from adopting compression, injections of acetic acid, or any other method of treatment by which the extirpation of the primary tumor, when feasible, is delayed. There are no serious objections to the operation, which do not apply to all other measures suggested for the treatment of cancer. To that of exasperating the disease it cannot seem exposed, in view of its natural proneness to sudden outbreaks independently of all treatment, the instances in which an operation appears to make no difference in its progress, and those in which the cancer, if recurrent, grows more slowly, and the fact that such an increase in the rapidity and amount of the cancer-growth as is contemplated in the accusation is never known, except when an operation has been abandoned, or outlying

nodules or the deepest part of a tumor already growing rapidly have been left. Such cases manifest the need which exists for the greatest circumspection in selecting cases for operation, not the impropriety of ever performing it.

The operation in cancer is wrongly appreciated if it be supposed to supersede those general measures upon which the subsequent maintenance of the health of the patient depends. A temporary failure of the health is eminently likely to prove the occasion for the recurrence of the disease. Attempts have been often made to retard that event by prolonging as much as possible the healing of the wound of the operation. No particular advantage has resulted from the procedure, which appears likely rather to invite than to ward off the dreaded return of the disease. A greater good may be asserted to have attended the establishment of a slight drain from some part of the surface, which is near enough to influence the locality of the disease, without being itself very liable to taint. The existing evidence appears sufficient to warrant the insertion of a seton beneath the shoulder, after the patient has recovered from the effects of the operation of removing a scirrhous mamma. It may also be well to wear a plaster for some time over the scar.

Treatment by caustics. — By means of caustics efficiently used, it is possible to destroy the vitality of a whole tumor, and obtain its complete removal; but the pain ordinarily occasioned by them forbids their employment when chloroform and the knife are not contra-indicated. Caustics exert no specially curative action upon cancer structures, but they present two advantages over a cutting operation. Their employment is not attended by an effusion of blood and the consequent exhaustion, or by erysipelas or pyæmia. And, further, in most cases they occasion a considerable emaciation of the healthy tissues adjoining the slough, and a diminution in the size of glands secondarily affected with cancer. Amongst many patients, treated in the Middlesex Hospital with caustic in the summer of 1857, there was a marked difference in the effects. In some it appeared to act in the same manner as erysipelas and hospital gangrene. Apparently, but in fact incompletely, removed, the disease reappeared in a few weeks; in those cases, however, in which caustics were carried through the cancer into healthy tissues, no such recurrence took place before the healing of the wound. After that event, the cases treated by caustic followed the ordinary course of cancer. Disease re-appeared, and death ensued as usual.

None of these results of the use of caustics differ materially from those which attend a cutting operation, and in cases which are equally adapted for either, British surgeons do not resort to caustics. There are some instances of advanced and ulcerated cancer, however, attended with suffering, but having adhesions which could not be detached with the knife; and in these a gradual insertion of caustic is sometimes followed by the complete enucleation of the tumor and cicatrization of the wound. In a case of medullary cancer of the parotid region, of very rapid growth, and so full of blood-vessels as to pulsate and bleed severely, the writer first tied the carotid artery, and then employed the caustic paste. The comfort and prolongation of life resulting from such treatment reconcile the patient to the temporary pain by which those advantages are gained.

If, on such grounds as the less probability of a fatal result from the mode of proceeding, it be determined to treat a primary cancer with caustics, the general rules must be observed which are applicable to the selection of cases for a cutting operation. The tumor must be primary, solitary, and uncomplicated with evident constitutional disease or infection of the parts around it. Should the absorbent glands be affected, the operation by the knife is decidedly preferable to that by caustics, as it is difficult to remove glands by the latter method.

There are various methods of cauterizing a cancerous tumor. If a liquid caustic be chosen, its application must be limited by some contrivance; as, for example, a hoop or cylindrical tube of gutta-percha, set on its edge around the tumor, and closely glued to the skin by means of a solution of the same material in chloroform. The caustic liquid, poured into the cup thus formed, or laid in it as a paste made with saffron or sawdust, will then burn through the diseased mass, the depth of its action being determined beforehand by the quantity of the caustic employed. The strong sulphuric acid and the fuming nitric acid produce a dry, hard, and much-contracted eschar, which separates spontaneously in the course of from one to four weeks, and leaves a granulating and cicatrizing sore.

Chloride of zinc may be made into a cake or a paste with flour, or may be employed alone. It can only be used upon a denuded surface. If the skin is entire, it must be first blistered or killed with the concentrated nitric or sulphuric acid. The chloride may then be laid over the tumor and allowed to penetrate through it. When the cancer is already ulcerated, the zinc-paste, diluted for the first application, may be soaked through cotton-wool and introduced into the ulcer. The

caustic, infiltrating the tissues, coagulates their albumen and blood, and produces a slough, which is friable, inodorous, and less dry than that resulting from the acids, but which separates in the same manner.

When white arsenic was employed, it was mixed with calomel, or bichloride of mercury, or merely with flour, and laid in very small quantity upon a raw surface over the cancer. Like the chloride of zinc, it is inert if applied to the skin. A very small quantity, not more than two or three grains of this caustic, was used at a time; but as it became absorbed, and some patients died in consequence, the use of it has been abandoned.

A convenient plan for extirpating a cancerous tumor, and one which keeps the action of the caustic within the control of the surgeon, is to lay the paste of the chloride of zinc within a cancerous ulcer, or on skin previously destroyed by a strong acid, in the manner already described, and, through incisions deepened daily as the slough extends, to introduce fresh quantities of the same caustic, until the whole tumor is perforated and destroyed. It is then cast off, and a healing wound occupies its place. The process is a slow one, and portions of the tumor are apt to be left behind and to require a renewal of the treatment. It is also sometimes incapable of overtaking the progress of a very rapidly growing cancer. But it is ordinarily less painful than any other cauterization, and is applicable in some cases in which a tumor is so situated that the knife could not be used. This, the effective part of the treatment introduced into England by Dr. Fell, of the United States, was described at length, and an estimate of its surgical value offered, in a Report on the Treatment of Cancer in the Middlesex Hospital in 1857. In making the paste, it is desirable to use a saturated solution of the chloride of zinc.

Mr. Shaw has favored me with the following interesting memorandum:—

"Mr. Whitbread introduced to Sir C. Bell a Dr. Chuna, son of a physician at Lisbon, and who treated *Cancer of the Face* with a powder called by his name. It was made up of one part of tartar emetic, and two of sulphate of zinc. It was used by scarifying along the outer edge of the ulcer, and filling the cut with the powder. It raised a great inflammation, on the subsidence of which the spreading ceased. I remember Sir C. Bell employing it in a rather elderly male hospital patient. The only effect I can recall is that great tumefaction and excessively severe pain followed, and that the results deterred Sir Charles from using it in any other case."

The hypodermic injection apparatus has been used by Sir J. Y. Simpson, for the purpose of injecting into tumors caustics in a liquid form, and by means of it he succeeded in destroying a fatty tumor. The same apparatus, employed independently by Dr. Broadbent, furnished the means of introducing solvents into the substance of cancers, and he has actually succeeded in dissolving away tumors of that nature in the living body. He selected the acetic acid for its known chemical effects on cancers under the microscope, and diluted it with three times its bulk of water. The injection of a few minims or a drachm into a cancerous tumor is moderately painful, but if any escape into the adjoining textures, the smarting is severe. After a temporary redness and swelling, the tumor is found smaller, and it may eventually disappear. By a single injection Mr. DeMorgan and I have each succeeded in obtaining such gradual diminution of cancerous tumors, which have not reappeared for two years and a half. That this remedy acts as a chemical solvent of the cell was shown by a specimen which I exhibited at the Pathological Society of London. (Transactions, vol. xviii., p. 236.)

Treatment by congelation.—Dr. James Arnott has recently given much attention to the subject of destroying cancerous tumors by the prolonged application of intense cold. A cup of gutta-percha, moulded to the surface around the tumor, and provided at its lowest part with a tube to drain off the melted liquid, is filled with ice. As soon as the surface of the tumor is chilled by this application, a mixture of ice, salt, nitrate of potass, and hydrochlorate of ammonia, which is capable of reducing temperature to a much lower degree, is substituted for the ice, and renewed as it melts during several hours. The result is a complete death of so much of the tumor as is reached by the cold. In a case thus treated for several hours by Dr. Arnott in the Middlesex Hospital, at the request of Mr. De Morgan, the tumor was found by incision to be quite dead to the depth of an inch. The patient described the treatment as causing no pain, and she ate her dinner during its continuance with apparent unconcern. No ill consequences ensued; but it was found impossible to affect the tumor by the cold more deeply than has been stated, and it became necessary to remove its deeper portion with caustic. Subsequent attempts to freeze cancers were less successful than this, which had been conducted by Dr. Arnott himself; and it was evident that the procedure, though the least painful of those which cannot be carried out under chloroform, was not yet made efficient, and is far too difficult of management to be generally available. Congelation may be employed

with great advantage in conjunction with caustic, of which it diminishes the pain without interfering with its action.

Treatment by pressure.—The effect of pressure on cancer is strikingly shown in some cancerous vertebræ taken from a patient of mine in the Middlesex Hospital, and preserved in the Museum. Some of the softened vertebral bodies have been completely squeezed away and absorbed, and the intervertebral subtances, not invaded by the morbid growth, or in any way unhealthy, lie in contact with one another. But the allegations which have been made as to the result of the treatment of cancer by means of compression have brought it into an unfavorable repute. Surgeons refuse credit to statements such as that of Récamier, that 30 per cent. of his cases were cured by it. That it is a method of treatment which is often valuable, cannot, however, be denied, whilst the strong opinions of Dr. Walshe, and other practical men who have largely used it, remain unqualified. Compression, according to those authors, greatly retards the growth of cancer, destroys adhesions, lessens enlarged glands, and sometimes entirely dissipates a tumor which is indistinguishable from scirrhus. Its value as a means of controlling pain was allowed by the surgical staff of the Middlesex Hospital, who systematically examined it, and reported on the whole unfavorably upon it. The method is certainly far from being always successful in repressing growth; adhesions sometimes form during the treatment, and the disease may on the whole advance. For recurrent cancers, though slightly ulcerated, compression is an advisable method of treatment. It may be made by firm and repeated bandaging over a thin metal plate, previously shaped to the surface and lined with a pad of felt or amadou; or, according to the plan of Dr. Neil Arnott, by means of a spring-truss, adapted in shape and size to the body or part to be compressed, and furnished with a concave metallic plate, with which to cover the tumor. Interposed between the tumor and the plate, a caoutchouc bag partly filled with air, or a bladder containing a thin paste of oil and linseed-meal, forms the actual medium of compression; and its application is more defined and its pressure more steady and direct, if it be encircled with a canvas hoop attached to the rim of the plate. The continuous application of such a pad can be borne if the pressure be light, not more than 2lbs. at first, and afterwards gradually increased.

Treatment by ligature.—In certain situations it is sometimes convenient to employ the ligature in removing cancerous tumors, or even portions of a tumor. The circumstances suited for the adoption of this plan are detailed in the articles on the diseases of special organs, as PENIS, TONGUE. The écraseur or the ligature may also be used to detach projecting portions of cancerous tumors, which by their mere position occasion inordinate distress to a weak patient. Large cancers of the upper jaw sometimes thus protrude into the mouth, and the removal of even a portion of them is a source of great, though temporary, relief to the patient, enabling him to close the jaw and to remove the tongue more freely than before.

THE MICROSCOPIC STRUCTURE OF TUMORS AND CANCER.

BY HENRY ARNOTT.

Revised by J. H. C. SIMES, M.D.

THESE drawings of the minute structure of Tumors and Cancer are not intended to represent the varied microscopic appearances of all such morbid growths, but rather to present the reader with a concise survey of the more typical forms of such diseases, classified according to the latest views on the subject. All these drawings were made with the aid of a camera, from sections stained with carmine and preserved in glycerine, taken from specimens either quite recent, or after being hardened in a solution of chromic acid. For the sake of convenient comparison, all

the sketches have been drawn on nearly the same scale, the exact magnifying power being noted with each drawing.

Fig. 28. Oval-celled Sarcoma. ×280.—This drawing represents a section from a large, soft, and rapidly-growing tumor, springing from the periosteum of the femur of a child, for which amputation at the hip-joint was performed. The left half of the sketch shows the structure of the mass of the growth—oval nuclei or

Fig. 28.

cells imbedded in a plentiful granular intercellular substance; whilst to the right is seen the gradual evolution of the oval cells from connective-tissue corpuscles. The nuclei of these are seen enlarging, whilst the delicate cell-walls and fibres are being transformed into a uniform granular matrix. A comparison of this figure with those of true cancer anatomically defined (in Figs. 40–45) will show

Fig. 29.

the difference at a glance. Nevertheless, it is important to bear in mind that this distinction is not a clinical one, since either structure may be equally malignant.

Fig. 29. Spindle-celled Sarcoma. ×220.—This sketch, taken from a large brain-like tumor in the abdomen, illustrates the typical structure of this form of growth. Seen indistinctly in mass, the delicate spindle-shaped cells are clearer where their tails bristle out at the margin of the section, whilst in the few detached cells at the upper part of the figure their real shape is more apparent. This tumor, like the last, though quite distinct in anatomical structure from true cancer, may yet, like it, be very malignant in its history, and it is particularly prone to recur *in situ* after even careful removal.

Fig. 30. Myeloid Tumor. ×280.—The tumor so called by Paget, on account of the likeness of its characteristic cells to those of fœtal marrow, is placed by Virchow in the group of Sarcomata, being distinguished as "large-celled sarcoma." The

Fig. 30.

basis of the growth is composed of elongated spindle cells, but irregularly interspersed amongst these are numerous large plate-like cells, containing many small oval nuclei with bright nucleoli and granular matter. The disorderly grouping of these elements is shown in the sketch, which also illustrates the various sizes of the larger cells. These characteristic myeloid cells are generally present in the sarcomatous tumors springing from bone, and are hardly ever met with elsewhere. The section was taken from a recurrent epulis of the upper jaw, a very frequent seat of this form of tumor.

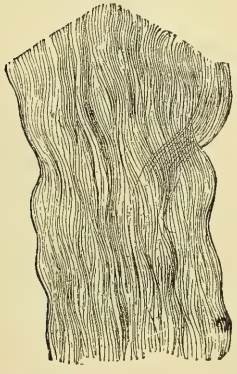
Fig. 31. Enchondroma. ×220.—This section, taken from a well-marked cartilaginous growth removed from the face of a girl, shows the usual structure of these tumors—large single cartilage cells in a

dimly-fibrillated matrix. The angular bodies imbedded in the matrix to the right of the figure are also very commonly met with. They have probably no connection with ossification, as might be suggested by their form, but seem to be rather the result of degeneration, or, in some instances, of imperfect development, approaching in character rather to connective-tissue nuclei than to the lacunæ of true bone. The cartilage-cells are often much larger than those here drawn (as in Fig. 35), and they may be invested with

Fig. 31.

faintly-marked concentric lines; and mingled with the large clear circular cells are generally many of the shriveled-looking branching nuclei, these being also usually larger than those in the figure. The matrix may be hyaline, dimly fibrillated, or coarsely fibrous, and is not unfrequently impregnated with earthy salts. The cells are commonly met with in clusters; and, mingling with the true cartilage-tissue in the same tumor, may be found gland tissue (in the case of cartilaginous growths in the parotid, for example), a jellylike semifluid, indistinguishable from myxoma, and, very frequently, not a little

Fig. 32.



true osseous structure. Indeed, there is a very general tendency to imperfect ossification in all enchondromatous growths.

Fig. 32. Fibrous Tumor. × 220.—This section was taken from a small fibrous growth in the scar left after the removal of a breast. It shows the fine wavy parallel lines characteristic of the most perfect form of fibrous tumor. Other sections from the same specimen exhibited fusiform cells and nuclei studding the fibrous tissue. These cells are usually present to a greater or less extent in all such growths.

Fig. 33. Lipoma. × 220.—The very simple structure of this form of tumor is here shown to consist of large nucleated oil-cells, somewhat altered in shape by mutual pressure. Amidst the cells connective tissue ramifies, the corpuscles of

Fig. 33.

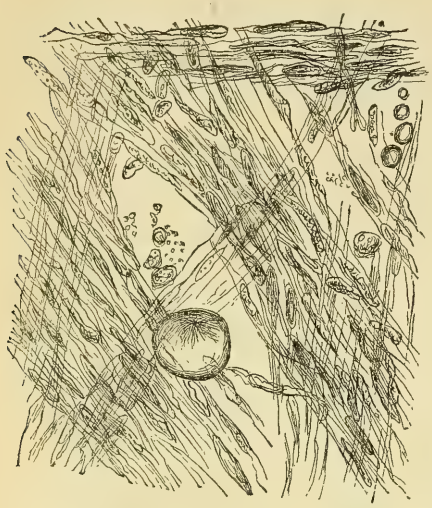
which are said to develop into the fat-cells. The large amount of crystallized margarine in the cells may be due to the preservation of the specimen in spirit, but it is said to be more abundant in these growths than in normal adipose tissue.

Fig. 34. Fibro-muscular Tumor. × 280.—This specimen, from an ordinary fibroid tumor of the uterus, serves to show the structure of the bulk of most of these growths. The interlacing bundles of plain muscular fibres are here quite free from any white fibrous tissue, such as is usually present in varying quantity. A few fat cells lie amid the muscular fibres, a large one in the centre containing a tuft of margarine cystals. [Cornil and Ranvier describe this variety of tumor, met with in the uterus, as a myoma with smooth fibres, or a leio-myoma.]

Fig. 35. Osseous Tumor. × 220.—This section, taken from an exostosis of some years' growth, springing from one of the tarsal bones, shows the general characters of such tumors, in the more or less well-marked bone-lacunæ and canali-

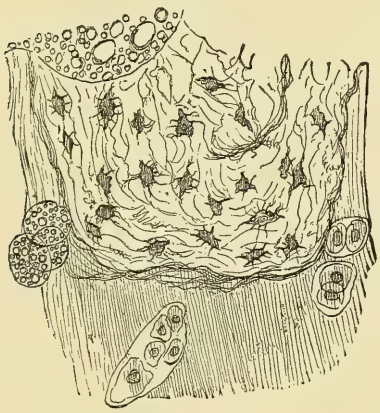
culi, often far more perfectly developed than in this instance; and it also serves

Fig. 34.



to show a common mode of growth, for it will be seen that the bony spicule is represented jutting into a thin layer of true cartilage. In those cases in which this

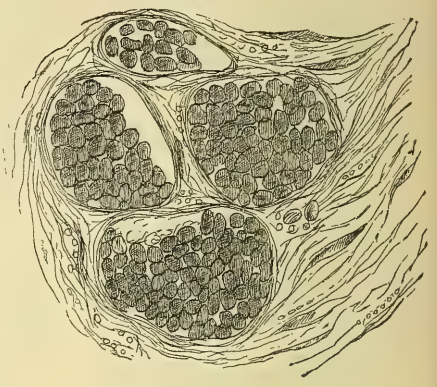
Fig. 35.



investing cartilage is not met with, the bone is formed by the ossification of layers of fibrous tissue, as in the natural ossification of certain of the skull-bones. Compound oil-cells are also present in this specimen.

Fig. 36. Glandular Tumor (of Breast). ×220.—This preparation, from an intracystic mammary tumor, serves to illustrate the typical form of these glandular growths, showing the very close imitation of the structure of the gland with which the growth is connected—the breast in this instance. Clusters of gland epithelium are seen lying in lobules or acini, which, lined with delicate simple membrane, are irregularly scattered through more or less perfectly-formed fibrous tissue. In the present instance this is

Fig. 36.



slightly fatty, and abundant elongated cells are visible. The fine filaments may be generally, as here, seen waving and arching between the lobules bounding them. The proportion of gland structure to the fibrous stroma varies with each specimen, and in different parts of the same section; but, wherever present, it is almost invariably in the form here represented, although occasionally occurring as fragmentary ducts lined with columnar epithelium.

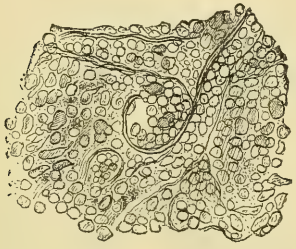
Fig. 37. Lymphoma. × 220. — This drawing was made from a section from the diaphragm of a man dying with tumors, varying in size from a bean to an infiltration barely visible to the naked eye, studding various organs—notably the kidneys and liver, and also the diaphragm. These masses, having the rough physical characters of cancer, were found to be made up of densely-aggregated clusters of nuclei precisely resembling lymphatic gland elements (hence the name given to this form of growth by Virchow). Fine sections of such tumors, when the cells have been carefully pencilled out, exhibit a very delicate reticulated stroma, which is particularly characteristic. It is probable that a certain amount of this structure is generally present (in early life at least) in the connective tissue in some positions, as in the subserous layers; and a greater or less number of similar nuclei may be sometimes found in the connective tissue in the neighborhood of any active morbid growth; but when in sufficient quantity (as in the present instance) to form defi-

nite tumors, it constitutes the disease Lymphoma.

Fig. 37.

Fig. 38. Glioma. × 220.—The specimen which furnished this drawing was taken from a rather soft tumor in the cerebellum. The drawing shows the usual appearance of the softer forms — small, round, oval, and perhaps pointed cells, lying in an abundant granular stroma, in

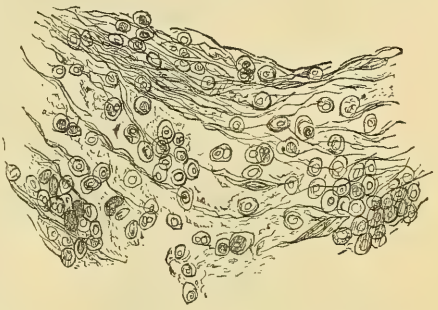
Fig. 38.



which are some traces of fibrillation, and a few remains of nerve-fibres. Other parts of the same section showed also small spindle and stellate cells. It is not uncommon to find in the same tumor the structures of both myxoma and sarcoma, together with the true gliomatous tissue.

Fig. 39. Myxoma. × 220.—The section from which this sketch was taken came from a tumor springing from the ischium, recurrent for the third time, and shows delicate fibrils, in the wide interstices of which are clustered small, round, nucleated cells of varying size, most of them having clearly-defined nuclei and nucleoli—others only granular contents. A few small spindle-cells are scattered through the field. In the clearer and more translucent forms of this tumor—as the flickering jelly-like masses rarely found lying thinly encapsuled amongst the muscles of the thigh and elsewhere—the structure is more distinctly that of embryonic

Fig. 39.



connective tissue, the delicate stroma being formed of large branched cells, giving off long anastomosing fibres of extreme tenuity, and so forming a wide-meshed web, the interstices of which are filled with a clear viscid fluid, having the physical and chemical characters of mucus; hence the name given to these growths by Virchow. In specimens like the one here represented, where loose cells abound, the external appearance of the tumor is more opaque, and its nature not always so easy to determine.

Fig. 40. Scirrhus (Hard Cancer) of the Breast. × 220.—The typical form of hard cancer—*i. e.*, cells of an epithelial type, of varying size and shape, but with tolerably uniform (and usually

Fig. 40.

single, large nuclei, closely packed in the meshes of a stout fibrillated stroma, without any visible intercellular elements. To one side of the section are drawn a few de-

tached and larger cells from another specimen of undoubted scirrhus of the breast, showing more clearly the varying shape and size of these cells, and their occasional multiple nuclei.

Fig. 41. Withering Scirrhus of the Breast. × 220.—This section was taken from an atrophied cancer of the breast, about the margin of which a recent, softer, rapidly-growing cancer had called for the removal of the organ. The "withering" is here seen to consist of a fatty degeneration of the cell-elements of the growth, a few shrivelled cells and nuclei alone remaining of what has been almost wholly converted into drops of oil of sizes varying from mere bright clustered points to globules larger than many of the original cancer-cells. To the left of the figure are seen comparatively unaltered connective-tissue nuclei, these having, as is not unusually the case, resisted the degenerative changes affecting the more highly differentiated structures.

Fig. 41.

Fig. 42. Medullary (Soft) Cancer. × 280.—From a lymphatic gland—secondary to hard cancer of the breast. This form of cancer differs from scirrhus only in the proportion of cell-element to the fibrous stroma, the cells being here seen to be still of the epithelial type, and lying close together without visible intercellular substance. The stroma of cancer, by many observers regarded as consisting of the compressed connective-tissue basis of the affected organ, would here (from its large amount) seem to be a new formation, and not a mere derivative from the lymphatic gland structure. This is the usual form of cancer affecting the axillary glands secondary to scirrhus of the breast, the structure of the secondary nodules often present in the liver, lungs, and other organs, resembling this more or less closely in the preponderance of cells over fibrous stroma.

Fig. 42.

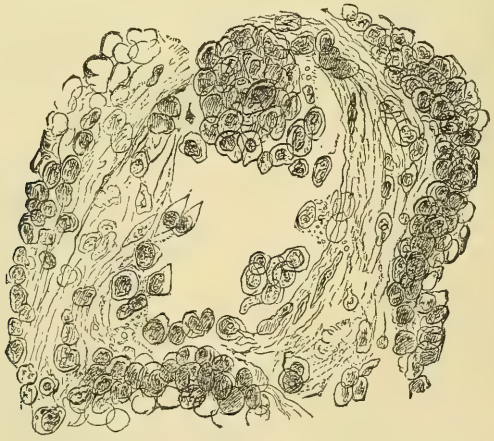
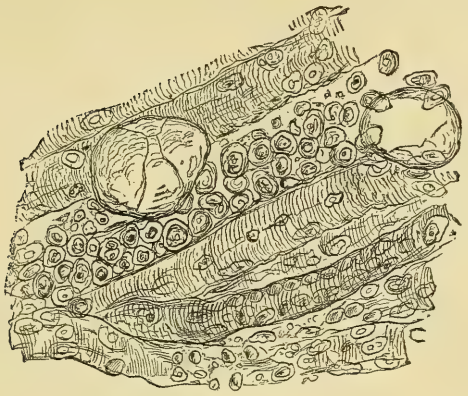


Fig. 43. Cancer invading Muscle. × 280.—Drawn from a section through the margin of one of many pea-like nodules in the pectoral muscle underlying a scirrhous breast. This serves well to illustrate the infiltrating character of cancer. In all the fibres an increase in number of the normal nuclei of the sarcolemma is seen—a condition usually present with any neighboring irritation—whilst one fibre seems to be almost filled with nuclei lying within the sarcolemma, and shining dimly through the striæ. Hardly any indication is left of another fibre, which is almost wholly converted into a mass of cells having the common character of the cells of

Fig. 43.



cancer, as above stated. The two large cells with bold outline are oil-cells, of which there were many scattered over the field of the microscope.

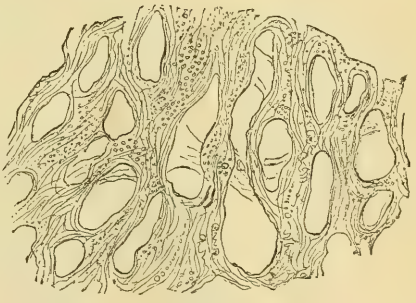
Fig. 44. MELANOSIS. × 220.—This specimen was taken from a woman who died, having upwards of two hundred rapidly-developing melanotic tumors over her body; the lymphatic system being also largely implicated, and one breast (a rare seat for this form of disease) being also involved, the original growth having sprung from a wart on the forearm. Although, clinically, extremely malignant, this case would rather be referred, anatomically, to the class of round-cell sarcomata, from the very general presence in other parts of the tumor of more or less of intercellular substance. In the same way not a few cases of so-called "melanotic cancer" be-

Fig. 44.

long to the sarcomatous group of tumors, many having a definite spindle-cell structure, and most of the others failing to exhibit the close grouping of cells in meshes of a fibrous stroma, above described as significant of true cancer. This anatomical distinction between true cancer and sarcoma, much insisted on by Virchow, is nowhere made with more difficulty than in dealing with a round-celled tumor like the present, which is specially and very naturally apt to be confounded with soft cancer, the sole difference being in the amount of visible intercellular substance. The black color of the tumors is seen here to depend upon an abundance of granular pigment inside the cells of the growth.

Fig. 45. CANCER STROMA. × 220.—A very thin section was made, through a tolerably firm pink-white cancerous nodule, in the liver of a patient dying with hard cancer of the breast, and the cells

Fig. 45.



brushed away with a camel's-hair pencil under water. There is thus left the typical stroma shown in Fig. 45, dimly fibrillated and granular, inclosing meshes which have been closely filled with cells; and apparently here, also, the stroma is as clearly a new formation as in the cancer of the axillary gland (Fig. 42).

Fig. 46. EPITHELIOMA. × 280.—This sketch shows an outlying cluster of cells near a cancerous ulceration of the mouth of the uterus. The variety of shape and bold contour of many of the cells and nuclei is as noteworthy as their disorderly heap-

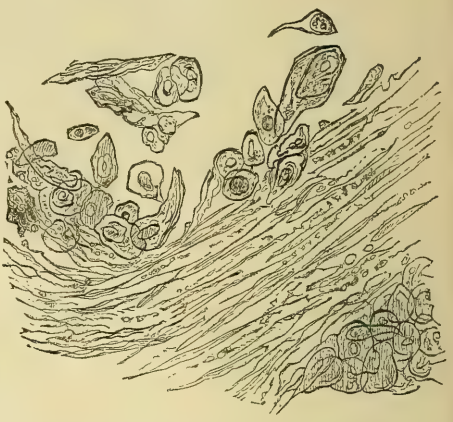
ing together in the midst of healthy-looking uterine tissue. This specimen is probably a variety of epithelioma, like that in the next figure, although many of the cells

Fig. 46.

are somewhat widely separated from the normal epithelial type; and the case was further remarkable for the existence of similar deposits in the pelvic and lumbar glands, and in the liver—a condition comparatively rare in uterine cancer.

Fig. 47. EPITHELIOMA. ×280.—This section was made through the border of an

Fig. 47.



epithelial ulceration of the cervix uteri, and shows with unusual distinctness the squamous epithelial elements of the morbid infiltration. The large size and diverse shape of the cells in the upper part of the

Fig. 48.

sketch illustrate the common character of the cells met with in this disease, while the confused heaping together of similar cells in another part of the field shows their more usual arrangement. Definite so-called "nests" are rarely met with in epithelioma affecting the uterus, though it is not uncommon to find the cells arranged in a more or less concentric manner. The structure here shown is probably that usually present in cancer of the os and cervix uteri, although it is very generally much obscured by inflammatory changes, and so often very difficult of recognition. In this

figure the uterine tissue in the neighborhood of the morbid infiltration is the seat of fatty granular degeneration.

Fig. 48. EPITHELIOMA. × 280.—This drawing is made from a section through a "Sweep's Cancer" of the scrotum, representing two "nests" ("laminated capsules," "globes epidermiques"), the larger one displaying the structure of these bodies — plump epithelial cells in the midst, surrounded by drier and flattened scales, which at the extreme margin are hardly recognizable; whilst the smaller shows a more common appearance, the cells being so flattened and altered as to resemble a ball of hair; both nests were imbedded with numerous others in the subcutaneous tissue. These bodies are commonly met with, in greater or less number, in all epithelial cancers, although not peculiar to this disease; and it would appear that where the epithelioma affects a mucous surface with cylindrical epithelium (as the intestine), the cells are of a cylindriform type rather than of the more usual squamous variety.

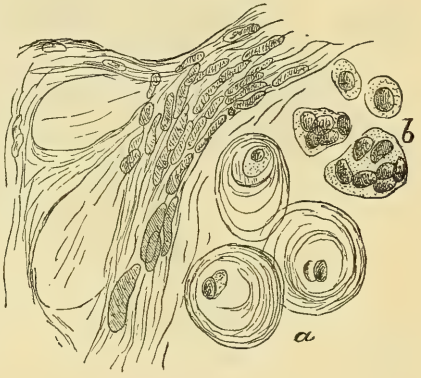
Fig. 49. OSTEOID CANCER (?) × 220.—This sketch was made from a section through a bony tumor, occurring in the lung of a patient, after amputation at the hip-joint for osteoid cancer of the lower end of the femur. It has been called osteoid cancer, but perhaps malignant osseous tu-

Fig. 49.

mor would more accurately express its nature. True osteoid cancer, as described by some writers, is infinitely rarely met with. The growth here drawn exhibits spicules of imperfectly-developed bone, shooting into a sarcomatous structure of round and spindle cells; and surrounding the bony tissue is seen a small-celled medulla-like structure, whilst the lower edge of the figure shows an arrangement of larger cells, in clear spaces, more nearly approaching cartilage in type. There is nothing here, therefore, to which the name of cancer can be strictly applied, although the growth was clinically malignant.

Fig. 50. COLLOID (ALVEOLAR CANCER). × 220.—In this sketch, elements from different sections of the same specimen of colloid disease of the stomach are grouped. To the left of the figure is a small bit of the wavy stroma which has gained for this growth the name of "alveolar cancer," fibrous bands forming meshes usually much larger than those here portrayed, and studded with rod-shaped connective tissue nuclei. Inclosed in these

Fig. 50.



meshes are found cells, of which the larger (*a*) are those most characteristic, round or oval, mono-nucleated, and having within the outer cell-wall several very delicate concentric lines, giving to the cell somewhat of an oyster-shell appearance. More numerous are the cells (*b*) which approximate more closely to the epithelial type, many of them large and polynucleated.

Fig. 51.

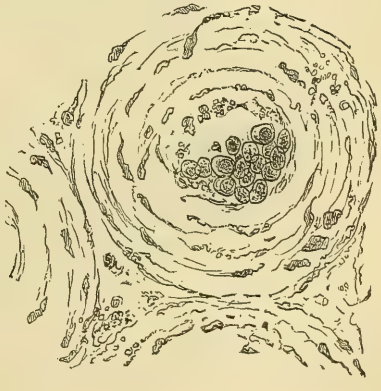
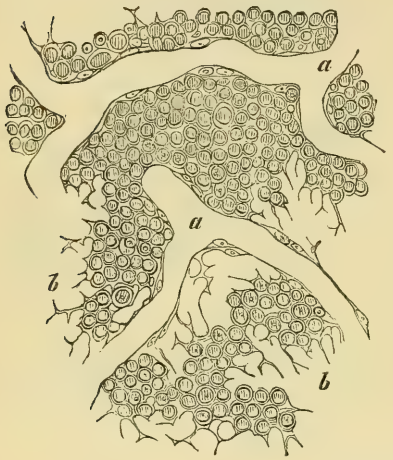


Fig. 51. Colloid. × 220.—This sketch, taken from a similar specimen to the last, shows another very common and especially characteristic appearance in this disease—*i. e.*, concentric circles rendered visible by the slender nuclei and granules dotting them, and inclosing in their midst a greater or less number of oval, well-defined nucleated cells.

[Fig. 52. Round Small-celled Sarcoma. (From Rindfleisch.) × 300.—

Fig. 52.

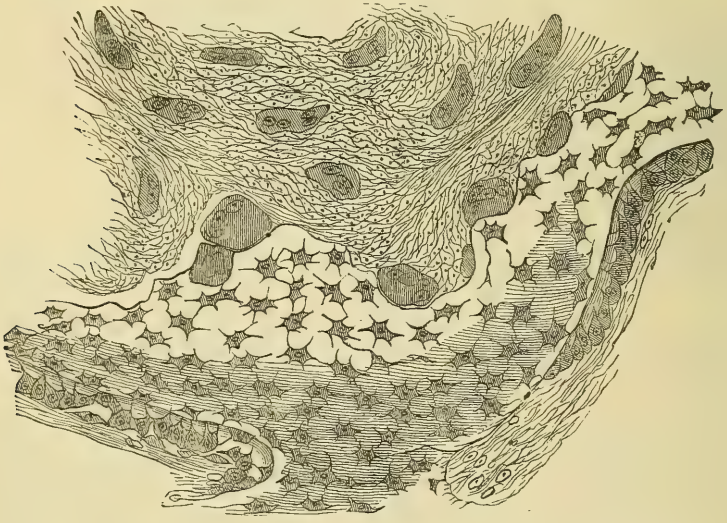


This variety of sarcoma is also named encephaloid, lymphadenoid, embryoplastic. The drawing, from Rindfleisch, shows the tumor to consist of small lymphoid cells usually round in shape, or, from mutual pressure, somewhat irregular. The intercellular substance is very scanty in amount, and can be seen only by teasing or pencilling a portion of a thin section, when we find it to be composed of a delicate reticulum of fibres, very similar to the intercellular network of a lymphatic follicle. This structure is seen in the drawing, at *b*. The vascular arrangement is peculiar in that the vessels are embryonic in nature, being, as it were, simply a flattening of the cells, thus forming channels for the blood, as shown at *a*. Frequently there occurs a rupture of the delicate vessels, giving origin to extravasations or the formation of cysts, constituting hemorrhagic and cystic varieties of sarcoma.

This variety of sarcoma is met with in the skin, subcutaneous tissue, intercellular connective tissue, bone, muscles, and in the glands. Clinically, it evinces a malignancy second only to that of the alveolar variety.

Fig. 53. Spindle- and Giant-cell Sarcoma. (From Rindfleisch.) × 500.—This is a vertical section of a large myeloid sarcoma of the lower maxilla. The drawing includes a portion of the tumor and an osseous trabecula, which latter, upon the tumor side, is undergoing absorption by the action of the myeloplaxes (giant-cells) placed in the contours of Howship's lacunæ. The situation of the

Fig. 53.



youngest myeloplaxes is so constantly at the inner edge of the bone, that Rindfleisch is inclined to consider them as metamorphosed bone-cells. The cells seen at the opposite side of the osseous trabecula are the osteoblasts of Gegen-

baur, and are producing new bone. Above is the tumor, consisting of spindle shaped cells interspersed with myeloid cells (giant cells).

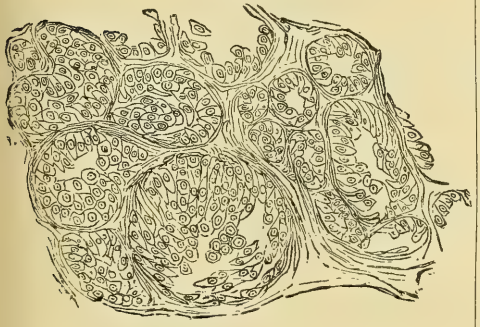
Fig. 54. Alveolar Sarcoma. (From Billroth.) × 400.—This variety of sarcoma differs from the others by its histological resemblance to the carcinomata. Indeed, Rindfleisch considers it a carcinomatous degeneration of a sarcoma, and names it *sarcoma carcinomatodes*. As is shown in the drawing, it consists of cells, which are lymphoid in type, almost epithelioid, arranged in the alveoli of a connective-tissue meshwork. This reticulum of connective tissue is best seen by pencilling a thin section. At some points the collections of cells are separated by bands of connective tissue, which form larger alveolar spaces. According to Billroth and S. W. Gross, this form of sarcoma is

Fig. 54.

distinguished from carcinoma, in that the cells are intimately connected with the walls of the alveoli or vessels which form them, and that by pencilling a delicate reticular intercellular substance, having its origin from the fibres of the larger alveolar walls, is revealed.

Fig. 55. Adenoma of the Mamma. (Rindfleisch.) × 300.—These neoplasms have their prototypes in normal glandular structure. They are composed of an ex-

Fig. 55.

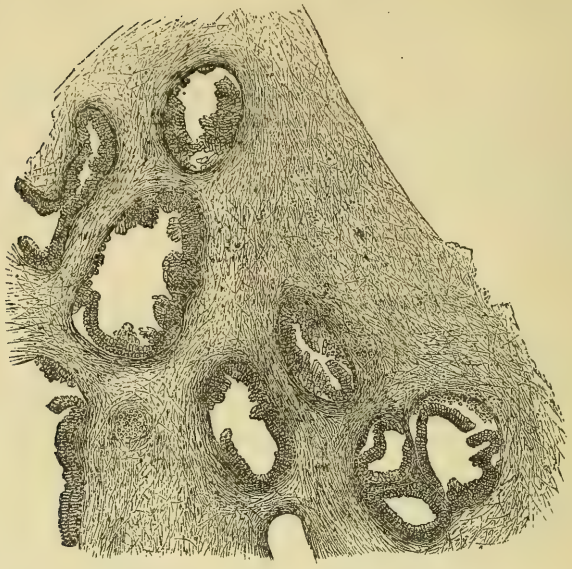


cessive development of ducts and acini, the latter usually very imperfectly formed. At times the lumen of the ducts and acini is filled with the proliferating lining epithelium, which frequently undergoes fatty degeneration. Between the enlarged acini and ducts is seen the peri-acinous and tubular fibrous connective tissue, which is not increased in amount. The limiting membrana propria, which separates the lining epithelium from the surrounding connective tissue, is intact in this variety of tumor, and serves as a point for differential diagnosis between it and the carcinomata. These growths are particularly liable to experience cystic changes.

Fig. 56. Adeno-fibroma of Mamma. (From Green.) × 100, reduced ½.—In this variety of neoplasm of the mammary gland, there is a new growth, both of the glandular structure and fibrous tissue. The acini, as seen in the drawing, are frequently much enlarged, constituting cysts, the walls of which are lined by epithelium. From the internal surface of these cysts are developed papillary outgrowths covered by epithelium, which grow into their cavity and form secondary cysts. The interacinous fibrous tissue in this section is formed of a fibro-cellular structure.

Fig. 57. Lymphoma. (From Bryant.)—This is a drawing from Bryant's Surgery, showing normal lymphadenoid tissue, which tissue is the physiological prototype of the lymphomata. These growths consist of a delicate reticular network of fibrous tissue. Within the

Fig. 56.



meshes of this network are seen numerous cells, lymphoid in character. The relative proportion of cells and reticulum varies in different growths; at times the amount of stroma or fibrous tissue is very much greater than the cellular elements, or the contrary may occur, the cellular elements preponderating over the fibrous tissue; the former is termed a hard lymphoma, the latter a soft lymphoma. Their

Fig. 57.

From submucous coat of Ileum partly pencilled

structure is best seen by pencilling a thin section, when the fibrous tissue remains as a delicate meshwork. An inflammatory hypertrophy of a lymphatic gland (adenitis) is not considered a lymphoma.

Fig. 58. MYXOMA. (From Green.) × 200.—In this form of myxoma we have a picture of embryonal connective tissue, showing the characteristic branched anastomosing connective-tissue cells, which

form by the joining together of their polar processes a reticulum, in the meshes of

Fig. 58.

which is placed the hyaline structureless mucoid substance. There are also seen a few leucocytes in the meshes of the network.

Fig. 59. Pavement or Squamous-celled Epithelioma. (From Cornil and Ranvier.) × 400.—Here are shown the dissected elements which constitute the neoplasm known as *cancroid epithelial cancer* or *epithelioma* of the skin and mucous membranes covered with squamous epithelium. To the right is seen an epithelial peg formed by an ingrowing of the squamous cells which cover the surface of the tumor. At irregular intervals upon the peg, the cells are arranged concentrically, and constitute the pearly bodies (cell nests). One of these latter is seen at *c*, crushed, showing its minute structure, and it is found to be made up of cells similar to those which form the peg. The isolated cells at *a*, many of which contain several nuclei, have been teased from an ingrowing peg.

Fig. 59.

Fig. 60. Tubulated Epithelioma. (From Cornil and Ranvier.) × 20.—This variety of epithelioma is composed of plugs or cylinders which anastomose one with another, and consist of squamous epithelium undergoing no epidermic evolution. The stroma consists of embryonal mucous or fibrous tissue. The cells constituting the plugs are small, of uniform size, and limited not by a sharp, but by a dentated border. By means of this dentation the cells are united together by dovetailing. At B two of the spinous or dentated cells are seen magnified 400 diameters.

Fig. 61. Cylindrical-celled Epithelioma. (From Cornil and Ranvier.) × 170.—This variety of epithelioma is met with, as a primary growth, only in mucous membranes which are normally covered by cylindrical epithelium, with the exception of those of the ovary. They consist of irregular tubular cavities

lined with cylindrical-shaped epithelium, *b*. The stroma, *a*, separating the tubules, consists of fibrous tissue. At *c* is a cystic cavity constituted by the union of two adjoining cavities. At *d* there is a constriction, a trace of the original intermediate septum. In the interior of some of the cavities is an amorphous mass, *e*, containing cells. The drawing is from a tumor of the large intestine.

Fig. 60.

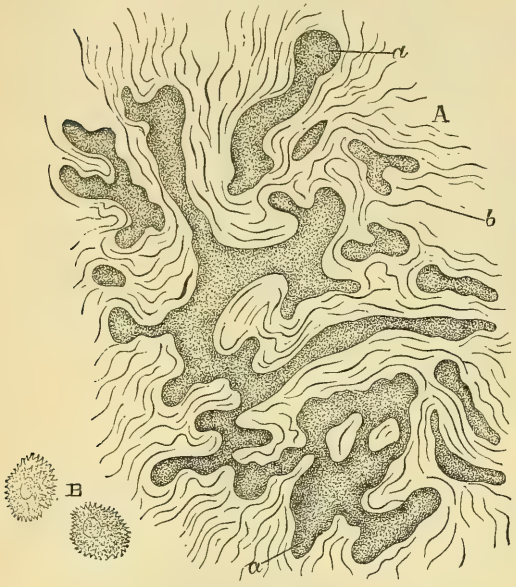


Fig. 61.

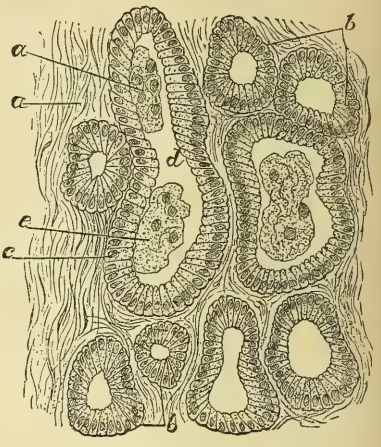
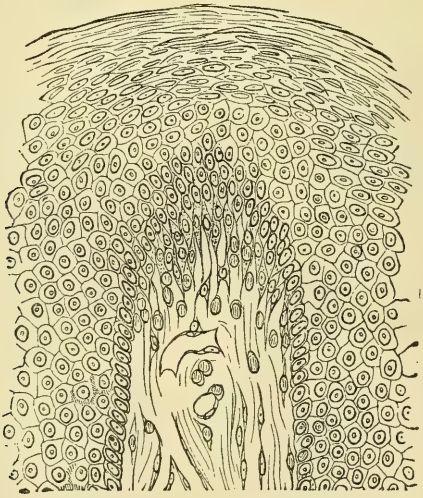


Fig. 62. PAPILLOMA. (From Rindfleisch.)—These growths have their physiological prototypes in the normal papillæ. They are constituted by a foundation of

Fig. 62.



connective tissue, in which are found the bloodvessels; covering this tissue are the layers of epithelium arranged as on the normal papillæ. The drawing represents a single enlarged papilla of the cutis, covered by laminated epithelium.]

PART II.

MORBID PROCESSES.

ABSCESS.
SINUS AND FISTULA.
GANGRENE.
ULCERS.

PART II.

MORBID PROCESSES.

ABSCESS.

By Holmes Coote, Esq.

Revised by P. S. Conner, M.D.

The object of the following essay is to lay down general rules for the guidance of the surgeon in the treatment of suppuration.

Speculative views as to the origin of pus might well be here omitted, were it not that in this, more perhaps than in any other subject, they have exercised an influence, not always beneficial, on rules of treatment and methods of practice. Our first inquiry, then, must be, what is pus, and what are its properties?

Pus, one of the commonest products of inflammation, is a creamy, yellowish-white fluid, neither acid nor alkaline: specific gravity 1.021 to 1.040. It consists of serum and pus-cells, or pus-globules. The serum contains more or less albumen, in all respects identical with that of the blood. The pus-cells, at first transparent when immature, become yellow from deposit of fatty matter when mature. The quantity of fatty matter in pus varies from 2 to 6 per cent.

If allowed to stand in a tall glass, it separates into a thick sediment and a supernatant serum: the latter is identical with the serum of the blood, inasmuch as it contains water, albumen, extractive matter, salts, and fat. The sediment consists of pus-globules—small spherical bodies, containing granular matter and one or more nuclei. The diameter of the entire pus-globule is $\frac{1}{300}$ in.: that of the nucleus $\frac{1}{600}$ in.

Pus thus constituted was called by the earlier writers healthy or "laudable;" but the fluid may present various abnormal or unhealthy conditions, to which reference shall be made hereafter.

What is the origin of pus? Does it come directly from the blood, to which, in many respects, it bears so close an affinity, or does it represent broken down or altered tissues, the waste of solid structures and organs?

In the early part of this century it was boldly asserted that the dissolution of the living solids of an animal body into pus, and the power of this fluid to continue the dissolution, were opinions which were no longer entertained by any well-informed surgeons of the day; and that the use of such phrases as "pus corrodes," or "it is acrid," etc.—expressions which imply an erroneous way of thinking—was very properly almost entirely discontinued in the language of every sensible medical man (Surgical Dictionary, by S. Cooper, p. 1050).

But in the time we now live in there are two prevailing doctrines as to the origin of pus, of which one brings to mind this dissolution of solid tissues. First, that the fluid is formed out of the exuded plasma of the blood (Rokitansky). Secondly, that it is formed by a rapid cell-growth, set up by irritation in the parenchyma itself (Virchow). The cells from which Virchow considers pus-cells to be generated are the corpuscles of areolar tissue (*Bindegewebskörperchen*), which he supposes to permeate nearly every part of the frame. This latter view is the one more generally adopted, although the universal existence of these corpuscles has yet to be proved.

Thus Weber describes pus corpuscles (as well also as the cells of lipomatous, sarcomatous, and cancerous growths) as originating from the connective-tissue-corpuscles by partition and endogenous production; and Förster describes and figures a series of new formations of various kinds, proceeding from connective-tissue-cells.

Henle, however, denies the existence of Virchow's connective-tissue corpuscles,

but admits that there are certain nuclear or celloid bodies, which seem to be the same as the nuclei of Virchow's corpuscles.

Fuhrer denies the universal application of Virchow's doctrine of cellular pathology; and in this position the question at present rests. Modern pathologists certainly do not regard pus as degenerated lymph. The white corpuscles of the blood, the lymph-corpuscles of the chyle, and pus-corpuscles, are identical and indistinguishable. They differ in their mode of origin. The two former are generated within a vascular system, normally. Pus is generated external to the vascular system, abnormally. Lymph-corpuscles, it has been positively affirmed, cannot escape from the blood, and pus-corpuscles cannot enter it, except by rupture of vessels; consequently the latter cannot be regarded as a degenerated form of the former.

Lately, however, the escape of the white corpuscles of the blood from the capillary vessels of the frog without rupture of the vessel has been noticed by Cohnheim.[1]

Whatever may be the issue of this cycle of opinions, one cannot lose sight of the many points of resemblance between pus and blood, both chemically and microscopically; and the time may yet come when a closer affinity between the two than now finds favor may be finally established. [This time came very soon. The correctness of Cohnheim's views of the migration of the white corpuscles having been established, almost all pathologists at once declared that pus was *not* generated externally to the vascular system, but that "pus-serum was the exuded liquor of the blood, and the pus-corpuscles all migrated white blood-corpuscles." Virchow's connective-tissue-corpuscle origin was believed in by but few. Further investigations, however, have shown that connective-tissue corpuscles do contribute in some measure to pus-formation, as also do the cells of all tissues "which experience a continuous renewal." Pus-corpuscles, therefore, may be regarded as coming chiefly from the blood by direct penetration of the vessel-walls, and in part arising from the proliferation of pre-existing cellular elements.]

Inasmuch as pus consists of myriads of cells swimming in serum and formed at the expense of the tissues, it follows that prolonged suppuration is accompanied by a corresponding amount of emaciation and waste of the body. But in all cases we must not lose sight of the causes tending to check assimilation and to arrest nutrition. The mere discharge of pus is often borne with tolerance, so long as the appetite remains unimpaired.

Pus may be readily removed by the absorbents. The serum is taken up as any other fluid. The pus-cells either dry up, when they form a cheesy pultaceous mass, which may ultimately become cretaceous, and has often been mistaken for tubercle; or the fatty matter undergoes granular disintegration, the cell-wall softens, and the whole is removed in the usual manner. During the early period of histological research, a doubt was very generally entertained as to the possibility of the absorption of pus; and a modern author endeavored to prove that it was an error to expect in surgical practice the cure of a large abscess without discharging the matter. He argued that bleeding, purging, vomiting, sweating, or other evacuations, often had the effect of causing the fluctuating tumor to vanish; but this, it was affirmed, was only for a time: "a large proportion of serum had been withdrawn from the contents of the abscess, and these had been reduced to little beyond cells; but as soon as the blood had recovered its natural constitution, the cells (just like the nucleated cells of glands) again exerted their power, and surrounded themselves with their natural atmosphere." It was further stated, that accidental circumstances will often act like the treatment to which reference has been made, and will reduce the fluidity of pus, so that an abscess apparently vanishes; but the cells may remain quiescent an indefinite time, and presently again surround themselves with fluid blastema, forming the same amount of pus as at first. On such grounds, it was pronounced that the perfect and permanent absorption of an abscess, consisting not only in the removal of its serum, but in the destruction and dissolution of its corpuscles, so that the part shall retain no tendency to re-accumulation of its previous contents, is "among the very rarest occurrences in surgical practice."

This opinion gained such ground that some of the journals thought it necessary to record well-marked cases to prove the complete disappearance of large purulent collections without incisions (vide Medical Times and Gazette, 1858, p. 295—cases under the care of Messrs. Hilton, Birkett, Critchett, and others.) No better illustration of the fact can be quoted than the certain and speedy absorption of purulent effusions under the periosteum, in cases of tertiary syphilis. The doctrine of treating abscesses by bleeding, purging, etc., has for many years been exploded, experience having shown that a cure can be more readily effected by the opposite course. About the end of July,

[1] See Appendix to the Essay on Inflammation.

1845, a young gentleman, aged twelve, was brought to the late Sir W. Lawrence, in consequence of his suffering from a large chronic abscess, three inches by two in diameter, situated just below the angle of the left scapula. There was stiffness of the vertebral column, and the abscess was made out to be connected with some morbid condition of the bone. A surgeon had wished to open it, but the parents objected. Rest in the recumbent position, the administration of tonics, and a generous diet, were directed; and on January 14, 1846, about six months afterwards, the boy presented himself again, when it was found that the abscess had completely disappeared.

[As shown by Sir James Paget, "abscesses are very apt to form in the seats of inflammation long past, especially where residues of pus remain. Such *residual abscesses* may form, as in the seats of past necrosis, with all the pain and constitutional disturbance commonly attendant on acute abscesses; but much more frequently they form slowly, and without pain, or fever, or any other distress. . . . The healing of discharged residual abscesses is quicker, and attended with much less disturbance than the healing of first abscesses of the same size and in similar situations."]

The time is not far back when the erroneous opinion here pointed out, induced surgeons to adopt the practice of opening the cavity of a joint distended by increased synovial secretion. Microscopic examination had proved the existence of pus-cells in the fluid of an inflamed joint, and their absorption was deemed impossible. The most serious consequences, often involving the loss of a limb, ensued from the proceeding, and the practice was speedily abandoned, save under exceptional circumstances.

[By the use of the aspirator the fluid may often be safely much diminished in amount and recovery promoted. When the joint-cavity is full of pus, such an abscess should be treated like any other, by free incision and thorough drainage.]

A question arises whether pus ever makes its way, in its normal state, into the veins, there to mix with the blood and join in the circulation. The experiments of Mr. Savory have shown that in animals the injection of healthy pus into the veins is positively innocuous, however severe the effects of septic matter may be. But we are told that pus not uncommonly makes its way into veins in some tissues which (like the cancellated structure of bone) abound with large veins, and some of these may have ulcerated, and have given entrance to the pus-cells; or, in another case, the vein may itself have been the seat of suppurative inflammation, etc.; and that, whether the admission of pus into the stream of blood have arisen in one way or the other, the results are uniform — the pus-cells are larger than the blood-corpuscles; they consequently become fixed in the smaller capillaries at which they next arrive, and give origin to what are called secondary abscesses. That fibrinous clots may be carried into the circulation and give rise to mechanical obstructions is a fact now well established, but the same conditions in reference to pus-globules have yet to be proved. It behooves us, therefore, to accept such views with caution, lest, by attaching to them an undue importance, we may be led from the better principles of treatment. Thus there are surgeons whose chief aim it seems to be to guard against the supposed peril attending open veins and the proximity of purulent matter, to the exclusion more or less of general hygienic principles; others allow the wounds no rest, as the secretion must be constantly removed; while others again, resort to medicated applications to arrest the secretion of that fluid, whose ill effects in its normal state have never yet been thoroughly proven.

Pus is not always of the same consistence or composition. It may be thin, though of yellowish color, when it is called *purulent* or *puriform fluid*. Pus stained with blood is *sanious;* when thin and acrid it is *ichorous*. It may contain cheesy-looking flakes, when it is called *curdy*. Pus formed in connection with diseased bone may contain, according to the late Mr. Bransby Cooper, 2½ per cent. of granular phosphate of lime. Dr. Gibb has related a case in which a purulent discharge of blue color, from the presence of cyanuret of iron, proceeded from the diseased breast of a female, æt. 23, a native of Canada.[1] The dressings were stained of a blue color. "The color," observes Dr. Gibb, "was of a light-bluish green. Caustic potash removed the color, which it will also do with Prussian blue. The color was not restored by dilute muriatic acid, which would restore that of Prussian blue. Except when in small quantity, muriatic acid removed the blue color, but without producing a pink solution. Immersion of a piece of the stained linen in dilute nitric acid removed the color." The pus was at times fetid. The discoloration lasted rather less than a month, disappeared, returned in about three weeks, and finally ceased before the patient's discharge from the hospital. Dr. Gibb has collected the particulars of ten cases, all presenting similar phenomena: two in the Gaz. Médicale, 1831 and 1834; M. Olioli's case in

[1] British American Journal of Science, New Series, vol. vi., p. 201, 1850–51.

Turin (amputation); a case in M. Maisonneuve's wards (breast); three cases in the practice of Sir Benjamin Brodie; one case (Dublin Journal of Medical Science) by Dr. Croker; one case by Mr. Butcher (Lancet, and Dublin Medical Press); one case by Dr. Gibb.

Dr. Gibb mentions other discolorations which have been noticed in pus, viz., orange-color, by Dr. Geoghegan—this fluid, however, proved to be "altered cellular membrane;" slate-colored pus, mentioned by the same author as a discharge in a case of abscess in the xiphoid cartilage—"it resembled the color and consistence of mercurial liniment;" black pus, described by Dr. Bigger;[1] green pus, common in abscesses of the brain; dark-olive pus, devoid of color, of creamy consistence, showing under the microscope decomposed pus-globules, mixed with epithelial scales (evacuated from an encysted tumor of the labium); claret-colored pus, from admixture of blood; brownish pus, from abscesses of the liver, etc.

[The investigations of Lücke, Girard, and others, have thrown much light upon the cause and nature of the changes in the color of pus not dependent upon the admixture of blood or bile. Blue pus "is the result of an epidemic and contagious process," there being produced under the influence of a determined contagium (the agents of which are vibrios) pyocyanine, which gives a blue color to the dressings saturated with albuminous fluids. This pyocyanine is of "definite chemical constitution, crystallizable, and altogether independent as to its origin of the coloring matters of the blood or bile. It spontaneously decomposes and develops a yellowish coloring matter, pyoxanthose; the varying proportions of pyocyanine and pyoxanthose simultaneously existing account for all the observed varieties of color. . . . So far as the wound itself is concerned, cyanochrosis is a perfectly harmless process."]

I cannot say that all these colors as applied to pus are familiar to me—particularly "black," "dark olive," or "slate," etc. Many cysts, however, present when large the characters of abscesses, and contain fluid or semi-fluid secretions of different hues.

The color of unmixed pus generally varies from light-yellow to white. The presence of blood in variable quantity will give any of the shades resulting from an admixture of red.

An abscess signifies a collection of pus situated in any of the tissues of the body, and circumscribed by a cyst formed of recently-deposited and newly organized fibrin. Pus may form under many other circumstances; as, for example, from a granulating surface; in the pustules of impetigo, herpes, smallpox; in the areolar tissue of a limb; in the cancellous texture of bone; in the sac of the pleura or pericardium, etc. To none of these conditions should the term abscess be applied; the expression "diffused abscess" is a contradiction. We draw a very proper distinction between diffused and circumscribed suppuration, regarding the term abscess as synonymous with the latter. We find in the examination of morbid specimens of the lung illustrations of what is here stated: a cavity formed by the softening of tubercle is not an abscess; nor is an infiltrated condition of a part of the lungs by pus, giving to the lobe a *general* yellow color. In the one case we speak of a vomica, or tuberculous cavity or cavern in the pulmonary tissue; in the other, of diffused suppuration. But an abscess in the organ exhibits a circumscribed cavity lined by a layer of membrane with a smooth inner surface. The causes of abscess are numerous; its symptoms, formation, and progress vary, not only according to situation, but also in connection with the previous condition of the individual. The surgical treatment requires in many cases the greatest amount of care, patience, determination, and skill. And before entering upon the subject more minutely, I would observe that the practice of invariably letting out matter as soon as formed is reprehensible.

Abscesses are divided into acute and chronic; but this distinction imperfectly expresses their variety. It serves, however, as a good basis of classification, if it be remembered that the two gradually merge one into the other. The former maybe taken as a type of the disease. A part, previously inflamed and swelled, becomes affected with a throbbing pain, mixed with occasionally sharper paroxysms; the skin covering it becomes glazed, shining, tense, and reddish or pink-colored; the patient's aspect is worn and pallid, and he suffers from shivering fits. Upon examination the surgeon finds a considerable amount of surrounding œdema, but towards the suppurating part the tissues are firmer and the pain more acute. If it were possible to have the view of a vertical section of an acute or phlegmonous abscess, we should see in the centre a collection of matter inclosed in an organized vascular membrane of variable thickness composed of fibrin, external to which would be seen serous effusion, gradually decreasing in quantity until it ceased in perfectly healthy tissues. However deeply an abscess may be formed, it enlarges by the extension of its wall towards the external integument or in the direction of some internal mucous or serous cavity.

[1] Dublin Medical Press, 1849.

When it approaches either skin or mucous membrane, it removes by degrees the bloodvessels which nourish those structures, by a process of thinning or attenuation: the most prominent part so thinned dies and separates as a minute slough, preceded by the casting-off of the epithelium. Thus a small circular aperture is formed through which the pus flows out. In the case of serous membranes the vitality is longer preserved, and the matter often escapes by a rent or tear. At first only a small quantity is discharged; but by degrees the stream becomes larger and uninterrupted, until, by the contraction of the cyst or wall of the abscess, the cavity is entirely obliterated. The external opening then closes and cicatrizes. Although much of the sharp throbbing sensation ceases when suppuration has been fairly established, still the process of *pointing*, or the coming of the abscess to the surface, is attended with much pain, and the surgeon may be called upon to assist nature by making an opening with a lancet or scalpel. Let him bear in mind the normal progress of an abscess, imitate the steps of nature as far as possible, and give the least amount of pain to the patient. He must first ascertain where the matter is situated. The feeling of fluctuation is more quickly perceived by one surgeon than another—a fact dependent upon the delicacy of touch. It is not necessary to grasp the part forcibly and to press upon the inflamed tissues with violence: fluctuation is more readily ascertained by gentle manipulation and slight yet well-directed, and sometimes alternating, pressure.[1] When the matter points, it is better to make that the seat of puncture, although it may not be the most depending part, for nature in general will not be interfered with, and the point which she has selected will ultimately burst and become the true outlet.

A bleeding-lancet is too small an instrument for opening abscesses. The surgeon should use a thin yet broad-shouldered sharp-cutting double-edged knife or scalpel. And having pre-determined where to make his opening, and the probable thickness of parts to be divided, he should plunge the instrument rapidly and boldly through the different tissues. If pus escapes by the side of the blade, he may, if he think fit, enlarge the incision to the requisite length as he withdraws the instrument. The pus must then be allowed to flow from the wound. There is no need of a probe, nor of any process of squeezing the walls of the cyst—a proceeding extremely painful to the patient. A soft poultice should be applied, and the remainder of the cure left to nature.

An abscess may now be opened, without pain to the patient, by the simple expedient of using the ether-spray. The integument is frozen in a few seconds, and then the introduction of the knife is not felt.

[Local anæsthesia may also be induced by the application to the part of chloroform, or better, pure carbolic acid, such application causing little or no pain and no injurious after-effects. Advantage may also be taken, much to the comfort of surgeon and patient, of the stage of primary anæsthesia from ether, to which the attention of the profession was called by Dr. Packard, of Philadelphia.]

There are some surgeons, who, in opening an abscess, hold the knife as if they were dissecting, and cut successively through skin, subcutaneous tissue, fascia, etc. Such a practice should not be tolerated; it shows ignorance on the operator's part, and aggravates the patient's sufferings to an unbounded degree.

[When the collection of pus is deep-seated and in the neighborhood of large vessels or other important structures, a safe and excellent method of opening it is that recommended by Mr. Hilton—viz., cutting through the skin and superficial fascia, then pushing a grooved director into the abscess and running along its groove a pair of dressing-forceps, separating the blades of which will enlarge the opening made by the director to such extent as to secure thorough evacuation of the pus. "In this way (wrote Mr. Hilton) you may open an abscess deep in the axilla or in other important parts of the body, without fear of inflicting any injury upon the patient."]

In all cases the constitutional treatment must be adapted to the peculiarities of the patient. But as a general rule, we may lay it down that any lowering system of treatment is inadmissible in the case of suppuration. Such measures fail to arrest, though they may disturb, the process which is going on; and we remark that recovery is the more rapid the nearer the patient's condition approaches that of health.

The practice of leeching inflammatory swellings has of late years greatly diminished. Patients are now allowed generous diet; and, in a certain proportion of cases, quinine, opium, wine, or porter. Thirty years ago it was the custom to administer lowering medicines, to order a spare diet, and not uncommonly to direct general abstraction of blood.

[1] For further remarks on fluctuation, see the Essay on Surgical Diagnosis.

The following case is interesting in illustration of the influence of the general health

upon the process of suppuration. In 1843 an officer arrived in England from India on sick leave. He consulted Dr. Latham respecting the condition of his lungs, but no conclusive evidence of disease was obtained on examination. Soon afterwards a swelling formed about the left pectoral region. In three weeks' time fluctuation was detected, the matter seeming disposed to reach the surface in two situations: first, about an inch below the clavicle and towards the nipple; secondly, in the axilla. An opening was made in the latter situation by Mr. Skey with a moderately large trocar, when about eight ounces of blackish-brown fluid were evacuated. Examined microscopically, this fluid was found to consist of blood-disks, fat globules, and serum. In about a week, his health being much improved, the abscess refilled, and, pointing under the clavicle, burst and discharged a quantity of healthy pus. The patient recovered.

Abscesses frequently form about the head, face, and neck. Such an occurrence is very common in childhood, when it is often associated with depressed powers of health, as after infantile fevers, or with that condition of constitution termed strumous. The question may be asked, should we open such abscesses early, or should we allow them to burst? About the scalp they are generally painful, when they may be opened; about the face a cicatrix may lead to unpleasant contractions; so that, as a general rule, we open them in the direction of the line of feature, or of the fibres of the subjacent muscle: for instance, when matter forms in the upper lid, as is frequently the case after erysipelas of the head and face, we make an early incision in the direction of the fibres of the orbicularis palpebrarum muscle. But the surgeon must dismiss from his mind the idea that a cicatrix formed in infancy will of necessity become obliterated, or even remain stationary, during the growth of the child. It will indeed contract for a time, and lose all that peculiar elastic material which was at first deposited, until it becomes a thin, smooth, white patch, differing clearly, but not very markedly, from the normal integument. "Thus a scar or a diseased spot may grow and assimilate as its healthy neighbors do. The scar of a child, when once completely formed, commonly grows as the body does, at the same rate and according to the same general rule; so that a scar which the child might have said was as long as his own forefinger, will still be as long as his forefinger when he grows to be a man."[1] Mr. W. Adams related to me the case of a young lady, who, when an infant, had a nævus removed from the left clavicle by extirpation. The surgeon assured the mother that the cicatrix would disappear with years; but on the contrary the scar has increased in length from an inch and a half to about four inches, and being situated on the bosom produces an unseemly deformity. But this is an exceptional case; and I am inclined to believe, with Mr. Paget, that "another rule within this is to be remembered—namely, that in these structures there is usually (especially in youth) a tendency towards the healthy state. Hence cicatrices, after long endurance, and even much increase, may, as it is said, wear out; and thickenings and indurations of parts may give way, and all become again pliant and elastic."[1]

Abscesses in the neck of strumous children are rarely attended with much pain. They form about the cervical glands, and make their way readily to the surface, where they burst, partially cicatrize, and burst again, until the tuberculous matter deposited in the glands has been discharged. Thus a series of deep puckered scars form in the neck, which are a great disfigurement in females. In course of years the red discoloration disappears and the integument regains its normal hue, but the marks are permanent. I do not believe that, as a rule, any good comes from opening these abscesses. [By timely opening, the deep, puckered, disfiguring scars may, to a considerable extent, be prevented.] The surgeon had better rely on general measures. In the adult, a large cervical abscess connected with tuberculous deposit in the absorbent glands not uncommonly indicates the existence of a similar morbid deposit in the lungs. This is especially the case when the matter has formed immediately above the clavicle.

But in young children an acute and extremely painful abscess may form behind the ear or below the angle of the jaw; the skin becomes of bright-red color, and the matter is obviously making its way to the surface. Here an incision should be made to relieve pain. The rule is clear in both instances. Surgical interference is required only when nature seems tardy in her proceedings, and productive of pain to the patient.

In the adult the neck is the seat of a deeper and more serious suppuration, which forms under the sterno-mastoid muscle and in the proximity of the great vessels. It generally terminates in an abscess—that is to say, a circumscribed suppuration; but occasionally the matter is diffused, when I have known the disease prove fatal, by interfering with respiration. It generally commences with stiffness of the neck, which the patient

[1] Paget's Surg. Pathol., vol. i., p. 50.

[1] Ibid.

refers to cold; then the head becomes twisted to the opposite side, by the action of the sterno-mastoid muscle, which is raised by the swollen parts beneath. The whole side of the neck may feel uniformly hot, hard, and brawny; or a mass of enlarged glands of nearly stony hardness may project from the posterior border of the muscle. The patient cannot open the mouth nor swallow in comfort; he cannot rest, nor clear his throat; he fears to sleep, lest he should choke. The countenance becomes pale, sunken, and anxious, and attacks of shivering are severe and frequent. Death may ensue from general purulent infiltration and swelling of the cervical glands and the adjacent areolar tissue, or by the abscess bursting into the œsophagus, pleura, or other important structure. A man, æt. 31, was admitted into St. Bartholomew's Hospital with pneumo-thorax on the right side and general emphysema. He had had pain in his throat and difficulty of swallowing some time before those symptoms ensued, which indicated the penetration of the pleural cavity. After death it was found that an abscess formed in the deep cellular tissue of the neck had burst in two directions—namely, through the upper part of the œsophagus, and through the right pleura into the cavity of the chest.[1] My colleague, Mr. Callender, of St. Bartholomew's Hospital, has dissected two cases of deep suppuration of the neck, in one of which the pus made its way into the anterior mediastinum; in the other, it surrounded the trachea and extended to the root of the lungs; and Mr. Ballard exhibited at the Pathological Society the remains of a tuberculous abscess which had burst from behind the sternum into the trachea. Sufficient has been said to show that the sooner the deep cervical abscesses are opened the better; the matter may be so deeply seated that the usual scalpel blade will scarcely reach it; but that does not signify, for the fluid will possibly find its way through the opening on the ensuing day. A case of this kind came under the care of the late Sir W. Lawrence, who entered his knife nearly the whole length of the blade without success. During the night the patient's sufferings became suddenly greatly alleviated, and in the morning the poultice was discovered full of healthy pus. The opening is more safely made behind than in front of the sterno-mastoid, and it usually happens that the fluctuation is more perceptible in the former situation. I saw a patient in St. Bartholomew's Hospital in whom a large purulent collection, inclining towards the posterior part of the neck, and causing the usual symptoms—throbbing pain, loss of sleep, etc.—had formed within a fortnight. I introduced the scalpel deeply, and gave issue to healthy matter; the patient recovered without an unfavorable symptom. But in many cases, especially if the patient be out of health and weakly, medical supervision should be continued for a considerable time. In the autumn of 1847, a lady, residing in the house of a surgeon in the city, went out in apparently perfect health to a party. She came home with swelled face, and it was supposed she was suffering from an attack of mumps. Some leeches were applied. Swelling and inflammation increased, and the family called in Sir W. Lawrence, in the belief that the disease was erysipelas. The neck soon began to swell, and an abscess formed, which was evacuated by puncture. Thick well-formed pus escaped from the incision in moderate quantity, and the opening soon closed. Then an abscess formed in the thigh, and pursued a similar course; next, another over the left scapula; and finally, a fourth formed over the hip. The ultimate result of the case was lost, the patient returning to the country. In this case there was possibly blood poisoning.

In 1847, a female was in St. Bartholomew's Hospital suffering from a cervical abscess, deeply seated, and raising the carotid vessels, which could be felt pulsating over it. There was numbness of both arms, and partial paralysis of the lower extremities. A puncture was made in consequence of impending suffocation, and from seven to eight ounces of thick matter were evacuated. This was followed by immediate relief to all the symptoms, and slow return of all the functions of the limbs. In another case the swelling was at the sides and front of the neck, and over the situation of the thyroid body. Wherever, in such cases, the matter may form, the treatment is the same. A proper opening must be made as early as fluctuation is detected, that the abscess may neither extend into the cavity of the chest nor burst into parts important to life. The application of leeches is rarely required, but from the general condition of the patient there is more frequent need of tonics and stimulants. Indeed, the administration of quinine and wine here seems to assist and to expedite suppuration, and, after an opening has been made, to favor the processes necessary to the closure of the wound. In all instances the state of the patient affords us a sure guide of treatment.

When abscesses form in the proximity of a joint, we have reason to suspect that disease is going on in the articulation. Not that the abscess of necessity communicates with the synovial cavity; but if

[1] Pathol. Catalogue, ser. xxiv. p. 14.

may be symptomatic of morbid changes in the soft structures or in the bone. A man came under my care, in whom there was a large suppuration under the deltoid and pectoral muscles; I evacuated the matter by puncture, and then ascertained that there was acute disease going on in the shoulder-joint. A similar case came under Mr. Stanley's care in 1857; and in both the severer disease was masked for a time by the painful suppurating swelling. The same remark applies to abscesses about the thigh; and we find that such an event may be the first indication of inflammation of the hip-joint assuming an acute form.

But the abscess may have a deeper and more serious signification. It may indicate the extension of some deep-seated suppuration through the articular cavity to the more superficial parts; and such a case as the following may point out the necessity of the most careful examination on the part of the surgeon. A boy was seen at St. Bartholomew's Hospital, in whom there was an abscess in the upper part of the right thigh pointing over the femoral vessels. Fluctuation extended into the iliac region; there was no pain in the hip, groin, or back. Mr. Stanley made an opening, whence there issued a considerable quantity of pus mixed with synovia, the latter separating and floating on the top of the former. Several openings were made at different times; severe pain in the knee came on, the boy became hectic, and died November 10, 1846. On examination it was found that suppuration, commencing in the iliac fossa, had extended through the acetabulum, destroying the hip-joint, and presented itself in the situation where it was first punctured.

In dealing with fluctuating swellings in the proximity of a joint, however, the surgeon must not be too hasty in the use of the knife. There are changes in the synovial membrane producing thickening and interstitial suppurations, which can with difficulty be distinguished from a circumscribed and external abscess. The synovial lining of the thecæ embracing the surrounding tendons may pour forth a considerable quantity of turbid fluid, or even of pus; and it may happen that the introduction of a lancet into such a collection will be followed by marked aggravation of the symptoms attending the articular disease. When abscesses form external to a joint, they are generally very painful, and are attended with heat and redness of the skin; the process of pointing soon manifests itself. An accumulation of fluid within a joint, or in the layers of the synovial membrane, or in the tendinous bursæ, rarely affects the integument, as in the preceding case; and the expression has become proverbial, that "external redness indicates the superficial character of the abscess."

The frequency with which abscesses form in the proximity of a wounded joint, during the processes of repair, is a fact pointed out by the late Mr. Hey: "When (after wounds) the capsular ligament becomes inflamed, the formation of abscesses, attended with a high degree of fever and ultimately a stiffness of the joint, are the common consequences if the life of the patient is preserved."[1]

The subject of psoas abscess is treated elsewhere.

There occur cases of abscess in the abdominal walls, some of which are unconnected with disease within the cavity. They may be left to pursue their own course, especially if they show a disposition to come to the surface. But, in dealing with such swellings, we must never forget the frequency with which they indicate intestinal disease. In the Museum of St. Bartholomew's Hospital there is a preparation[2] exhibiting a portion of the abdominal walls from the right iliac region. The anterior part of the cæcum is united to the peritoneum lining the adjacent muscles; at this part also the mucous membrane of the cæcum is removed, and irregular fungous growths occupy its place. A fistulous canal extends from the cavity of the cæcum through the middle of the growths, and through the adjacent part of the abdominal wall. The patient was a man thirty-five years old. The effects of an abscess bursting into the peritoneal cavity are fatal.

A case was related at the Medico-Chirurgical Society, April 22, 1845, in which Mr. Howell, of Risborough, found in the groin of a man aged 70, suffering from symptoms resembling those of strangulated hernia, a small hard tumor, about the size of a hen's egg, lying over Poupart's ligament, about midway between the external and internal abdominal rings. After two days, phlegmonous inflammation took place; and on fluctuation being perceived, the part was opened and four ounces of pus were discharged. On the following morning two worms (*lumbrici teretes*) were found in the poultice. Feces passed by the wound for three weeks; but the man recovered within two months. During the debate which followed, Dr. Chowne remarked that he had seen a case in which two ounces of quicksilver escaped from an abscess which formed in the groin of a patient who had taken much of this mineral. Fecal matter passed also for a time, and the wound ultimately closed.[3]

Many years ago I examined the body of a young lady, who died under the following circumstances: She had been some time previously in the south of France, where she suffered from a dysenteric attack. She, however, apparently had recovered, although

[1] Hey's Surgery, p. 355, 1814.
[2] Ser. xvi., prep. 28.
[3] Vide Lancet, 1845, p. 648.

she often complained of sudden pain and cramp in the abdomen. One day, while on horseback, she leaped over a small trench, when severe and agonizing pain immediately ensued over the whole abdominal region, and she could scarcely reach her home. She dropped from her pony, and died very soon afterwards. On examination it was found that a large abscess had formed in the pelvis between the fascia and peritoneum, and had been separated from the abdominal cavity by the thin wall of the sac. The sudden jerk had ruptured the abscess internally; pus had escaped into the abdominal cavity, and peritonitis of the acutest form had supervened, under which she expired.

[Perityphlitic abscess is not infrequently met with; its prognosis is grave, and surgical treatment at the proper time affords the patient a very much better chance for life than does non-interference, the relative mortality being perhaps as one to four or five. The operative procedure is much the same as that for ligation of the iliac artery, and the general opinion of American surgeons, and they have had most experience in this, is that the incision should be made about the seventh or eighth day of the disease.]

Dr. Deutsch[1] observes, "that to the frequently-occurring puerperal metastases belong abscesses, which are characteristic, inasmuch as they are often the local metastasis of a general 'blood-crasis,' exciting puerperal fever. In a great number of cases no inflammatory attack precedes their formation; and the presence of pus is first indicated by a rigor. So difficult of detection are these collections that the most careful examination, not only externally, but also by the vagina and rectum, are often necessary." He divides pelvic abscesses into peritoneal and extra-peritoneal. The former is, in general, attended with a febrile attack and acute local pain, and appears (1) in the inguinal fossa, more often the right than the left; (2) in the ligamentum latum, also more often on the right side. In the first situation there is an external swelling; in the second, there is none, and pressure adds but little to the pain. But examination by the rectum detects the feeling of fluctuation, and likewise produces severe pain, as does also lying on the opposite side, and the evacuation of the feces. In these cases we have generally adhesion to the rectum, rather than to the vagina or bladder. The extra-peritoneal abscess usually manifests less febrile reaction and an inconsiderable amount of pain. Its most frequent seat is (1) the spot where the aponeurotic covering of the deep abdominal muscles going to the thigh passes into the fascia transversalis abdominis and Poupart's ligament. Examination by the rectum fails to give any information; that by the vagina is useful only when the abscess is situated on the iliacus internus. In course of time the abscess extends upwards towards the inguinal region, when its presence soon becomes evident. (2) In the pubic region near the recti and pyramidales muscles, where their presence excites pain. The extra-peritoneal are more common than the peritoneal abscesses in the proportion of two to one.

Inguinal abscesses are readily detected externally. When pelvic abscess occurs in the female, the spot at which fluctuation is generally for the first time perceived is, according to Sir J. Y. Simpson, the roof of the vagina immediately behind the cervix uteri, or to one side, as if where the broad ligament would open below if its layers were separated by accumulated fluid. "The exploring needle," observes that distinguished physician, "which is of invaluable service in the examination of diseases, is never used to more advantage than when employed for the exploration of pelvic abscesses, when they happen to be unusually difficult or doubtful in their diagnosis. For in the common run of cases you will usually be perfectly able to make out the diagnosis without this assistance. In any case of pelvic cellulitis, however, where you are in doubt as to the formation of pus, you may make sure of it at once by pushing an exploring needle into the centre of the tumor."[1] The author continues, that "the best exploring needle is a long, slender thread-like trocar with a wire stilet passing through it. If the pus is thick, it may not traverse the trocar. But if the surgeon, after withdrawing the trocar, blow through, a drop or two may escape from the end. The existence of matter having been established, it should be evacuated by a free incision."

[Aspiration may be more advantageously resorted to for diagnostic purposes.]

Abscess of the brain may be a result of direct violence to the cranium, or happens as a consequence of disease of the temporal bone. A man who had had purulent discharge from the left ear for five weeks died suddenly. On examination, the petrous portion of the temporal bone was found extensively diseased. In the left hemisphere of the brain there was a cyst, an inch and a half in diameter, containing pus. It was situated immediately over the fissure of Sylvius; the walls were distinct, thin, and smooth on both surfaces, and easily separable from the surrounding cerebral substance.

Abscesses in the loose areolar tissue at the back of the orbit, causing protrusion

[1] Prag. Vierteljahrschrift, lvii. S. 63; 1858.

[1] Med. Times and Gazette, July 16, 1859.

of the globe of the eye, are treated of in the Essay on DISEASES OF THE EYE.

Mammary abscesses may be acute or chronic; superficial, deep-seated, or between the gland and the pectoral muscle. In whatever situation they may form, the treatment is to be conducted on precisely the same rules as affect abscesses in other parts of the body. Most commonly suppuration occurs during the progress of lactation, the patient being of feeble constitution and reduced below the usual strength. Among the poor we frequently see an abscess, occupying a large part of the gland, and formed within six weeks of delivery. The patient's face is pallid and worn; the pulse excessively feeble; the local pain is described as excessive, and the strength seems quite exhausted. Suppuration may be checked, and indeed prevented, by the timely administration of tonic remedies; but in general, sooner or later, the matter forms, when it should be evacuated by a tolerably free incision. Some surgeons fear to use the knife, lest they should injure the lactiferous tubes. Such a dread is imaginary: far more injury will ensue to the organ from the enlargement of the walls of the abscess.

The deep-seated chronic mammary abscess is peculiar in its slow growth, the absence of inflammatory symptoms, its firm, solid, and circumscribed feel, and its liability to be mistaken for a tumor. The cyst-wall is often very thick, so that it is impossible to detect fluctuation. I have seen the entire mammary gland removed by an experienced surgeon under the idea that the tumor was of cancerous nature, and other cases in which such an accident was on the point of happening. An incision made before the more serious operation, but in the same line, will generally yield the necessary information.

Abscesses seated between the mammary gland and the pectoral muscle mostly depend on tuberculous deposit. They form and burst not uncommonly near the outer border of the mammary gland. Sinuses extend in different directions, and the discharge is for a long time uncontrollable. The patients are for the most part young, and of strumous habit; in many instances there is tuberculous deposit in the lungs. In former times the practice consisted in laying open the sinuses, although this operation required the division through its entire thickness in more than one direction of the whole gland. I hope that this practice no longer exists. The sinuses are but the channels through which the tuberculous matter is washed away; the pus is but the agent for that salutary process; and when in course of years the parts have resumed their normal state, the openings will close without difficulty. We have here but a repetition of the tuberculous deposit as witnessed in the cervical glands. The administration of tonics and of nourishing diet, removal when possible to pure air, combined with unirritating applications and patience on the part of the patient—these are proper measures on which we may place the greatest reliance.

[These abscesses, unconnected with lactation, though the subjects of them often if not generally are of strumous or tubercular habit, mostly do *not* depend on tuberculous deposit; but upon either contusion, inflammation of the ribs or their periosteum, or, at times, perforating abscess of the pleura. Few surgeons will see in the pus "but the agent for the salutary purpose of washing away tuberculous matter." Free evacuation of its contents and thorough washing out of the abscess-cavity, with careful compression, will greatly lessen the duration of the disease, and promote the closing up of the sinuses.]

Acute idiopathic abscess of the testicle is extremely rare. There are two preparations in the Museum of St. Bartholomew's Hospital (series xxviii.) worthy of attention. The first (No. 34) exhibits a testicle enlarged and indurated, with a small circumscribed abscess in the interior. The second (No. 45) shows a testicle, in the centre of which there is an irregular circumscribed abscess, from which a fistulous passage extends through the tunics of the testicle and scrotum. The substance of the testicle around the abscess is indurated. The history of these cases, however, is imperfect, and they may serve only to illustrate the progress of tuberculous deposit.

The progress of tuberculous deposit in the testicle, such as leads to suppuration, is slow and attended rather with discomfort and a sense of weight than with absolute pain. A dragging sensation extends along the spermatic cord, and the patient cannot bear pressure. As the morbid deposit softens and approaches the surface, the integument becomes thin, red, and tender; but the pain is generally such as may be readily borne. The surgeon may make an opening if he think fit, but he should remember, and warn his patient against, the possibility of protrusion of the tubuli seminiferi. For a further account of this disease the reader is referred to the Essay on DISEASES OF THE MALE ORGANS.

The treatment of abscesses about the urethra, prostate gland, or rectum, will be found more fully described under their respective headings. I may here remark, that in most instances a free and early opening is indicated, not only for the relief of pain, but to prevent damage to important organs. An abscess of the perineum may be far from the surface; there may be neither pointing nor marked redness of

the skin; fluctuation may be very indistinct; but the pain is deep-seated and heavy; and examination finds the skin brawny and resistant. The patient should be put on his back with the knees raised, and a knife should be entered deeply either in the mesial line, or obliquely as in the lateral operation of lithotomy. The pus is often thick and generally fetid, and its evacuation affords the patient great relief. In 1857 I saw a case in which a large collection of matter presenting at the nates had been allowed to extend so as to occupy two large cavities, one extending to the posterior aspect of the pubes, the other passing backwards to the coccyx and almost "dissecting out" the pelvic viscera. The rule of procuring an external outlet for the matter as early as possible is obvious, for the case assumes a much more serious character when the neighboring viscera become affected. Many cases occur in which disease commencing in the hip-joint extends to the interior of the pelvis, where it excites suppuration, which ultimately bursts into the rectum; or the whole circumference of the bowel may be thickened, and permeated with fistulous passages. Abscesses in connection with disease of the rectum, on the other hand, may extend into the bladder,[1] or into the peritoneal cavity,[2] when death ensues from acute inflammation of the serous membrane.

Among the rarer forms of abscess requiring immediate opening are those termed retro-pharyngeal. The following case illustrates the disease.[3] A powerful young man, aged fifteen, experienced pain and swelling at the back of the throat, with inability to turn the head or to open the mouth. There was a painful swelling in the region of the right parotid; the tonsils were normal; there was no fever. For the first fourteen days the symptoms were sometimes severer, sometimes easier; on the sixteenth day there was hemorrhage from the mouth and nose; on the eighteenth spontaneous opening of the abscess, with discharge of a quantity of bloody, wine-lees-colored matter. Behind the soft palate the swelling was still visible. After some hours, about a pint of bright blood suddenly flowed from the mouth and nose—its source was never discovered. Four days afterwards there was a fresh discharge of blood, in this instance from the mouth alone, and on the following day a yet severer hemorrhage from the nostrils. The external swelling became larger and more painful. The abscess opened a second time in the fourth week, under precisely similar circumstances, with ease to the patient, the cessation of cough, etc. The internal swelling pressed the uvula forwards, but diminished in accordance with that situated externally. The patient died suddenly during the night from severe hemorrhage, which had recurred after an interval of fourteen days. On examination after death, a carious piece of bone was found on the front surface of the body of the atlas. In the cellular tissue, between the tonsil and parotid gland and about the branches of the carotid artery, there was a cavity the size of a hen's egg, filled with bloody coagulum. The immediate source of the hemorrhage was still uncertain. There were two small openings through the wall of the abscess into the mouth.

[The existence of retro-pharyngeal abscess, especially in young children, may very easily be overlooked, the case oftentimes being mistaken for one of laryngitis. Always secondary, this variety of abscess is generally consequent upon vertebral caries, or inflammation of the lymphatics. Death may be caused by pressure upon the larynx or trachea, or by the entrance of pus into the larynx. The locality of these abscesses has been found occupied by hæmatoma and aneurism (in one case, at least, of the internal carotid), so that great care should be exercised in the establishment of the diagnosis. Spontaneous opening should not be permitted to take place.]

The formation of abscesses may occupy either a few days or several months; and we are justified in applying to the former the term "acute," and the latter "chronic;" but we must remember that between these two the "shades are infinite." The following is a good illustration of a chronic abscess: "A healthy-looking girl, aged nineteen, experienced sharp, darting pains in the left buttock eight months previously. She soon after noticed a swelling, which has gradually increased up to the present time. When quite quiet she is easy, when she walks she limps, and feels pain. The integuments, loose and healthy, cover a tumor the size of the closed fist, hard and apparently bony, but with one softer point, attached to the left ilium near the sacro-iliac symphysis. There is no preternatural heat, nor is the part painful when examined. The girl has once experienced difficulty in making water." She was ordered generous diet and quinine, and rested in bed, poultices being applied from time to time. In the course of a month one part became more prominent and fluctuating; and in the course of a few days a large collection of fluid was detected. The patient went to the seaside, where shortly afterwards the abscess gave way and discharged itself. The last accounts of the girl were that she was con-

[1] Mus. St. Barth. Hosp., ser. xvi. prep. 34.
[2] Ibid., ser. xvi. prep. 69.
[3] Würtemb. Corresp. Blatt, xiv. 1858.

valescent. The interesting point in the case is the length of time which elapsed between the first symptoms and the clear manifestation of the disease.

The term *abcès froid*, cold abscess, is applied to such a case as the following: A man, aged 65, while nursing his wife, who was dying of a lingering disease, fell from a chair, overpowered with sleep, three weeks previously. He was admitted into St. Bartholomew's Hospital, April 7, 1857, with a large abscess, unattended with heat, redness, or pain, situated in the right thigh. An opening was made by Sir W. Lawrence, and *three quarts by measurement* of thick purulent fluid were evacuated. The opening was then closed, and the case ultimately did well. Such abscesses may form in any part or tissue of the body. They may be small or large; the cyst thick or thin. They may slowly come to the surface, or remain stationary for years. The cyst may be so full as to present a tumor of incompressible hardness; or it may be thick-walled, and contain only a moderate amount of fluid. In the latter case it may, upon examination, convey to the fingers the sensation of a sharp rim of bone with a depressed centre, such as is common in cases of extravasation of blood under the scalp. Mr. Erichsen attended with Dr. Boott a gentleman who had a large abscess in the iliac fossa, which had been perfectly stationary for nearly two years. "In the cancellous tissue of bone," observes the same surgeon, "abscesses may exist for an indefinite period, unless opened by surgical operation." To Sir B. Brodie is due the merit of first directing the attention of the profession to the last class of cases, and of pointing out how relief is to be obtained from pain by the timely use of the trephine, as well as how the extension of the disease toward a neighboring joint is arrested by the evacuation of the cyst (*vide* DISEASES OF BONE).

[Three years before Sir Benjamin Brodie made his first operation, Dr. Benj. B. Simons, of South Carolina, had reported (Carolina Journal of Medicine, Science, and Agriculture, Charleston, S. C., Jan'y, 1825) seven cases of successful trephining of the tibia for bone-abscess. "But prior to both Sir Benjamin and Dr. Simons, Bromfield, of Sir Benjamin's own hospital, St. George's, had described, in his work on surgery (1773), the symptoms which should lead the practitioner to suspect the existence of abscess of bone, and had taught that the operation of trephining in such cases should be substituted for amputation" (Blackman, Abscess in Bone).]

Inflammation and suppuration of the hand scarcely comes under the strict definition of an "abscess." The same remark applies to suppuration within the thecæ of tendons. In both these instances we commonly have an absence of that distinct cyst which gives to an abscess its distinguishing characteristic. Yet we should not pass over in silence so important a disease, which, as it occurs for the most part from accident, in the vigorous and healthy, requires some peculiarity in treatment. Acute inflammation of the hand may supervene on a comparatively trifling injury, such as a wound with a small splinter of wood, or a scratch with a piece of bone. In the course of a few days the hand and forearm become red, swelled, and tense, the former being by comparison twice the thickness of the normal member. Abscesses may form both on the back and palm of the hand; or suppuration may ensue in the thecæ of the tendons, and spread under the annular ligament among the muscles of the forearm. The hand is heavy; the fingers stiff and semiflexed; the patient is deprived of rest, and has no appetite; the tongue is furred, and the pulse of the affected side beats with twice the fulness and force of that on the opposite. If the disease be not checked, the tendons slough or become contracted; the muscles get glued together; portions of the phalanges may die and exfoliate; and the patient, after months of suffering, recovers with a useless limb. From considerable experience in the treatment of these accidents, I should say that the abstraction of blood from the inflamed limb most effectually relieves the engorgement of the blood-vessels. The pain, previously excruciating, becomes more supportable, while the parts are soon ready to assume their normal state. In the class of cases here alluded to we have not so often to deal with an enfeebled constitution. The attack is of purely local origin, and is proportionately sharp and severe. It is surprising how small an amount of disease, in this part of the body, will excite almost insupportable suffering. During the month of October, 1859, a woman who had had suppuration at the end of the last phalanx of the forefinger, came to St. Bartholomew's Hospital. For several days and nights she had been ceaselessly racked with pain, which nothing except large doses of morphine could alleviate. In more violent forms the inflammation may spread to the wrist-joint, when death of the carpal bones ensues, and the movements of the hand become permanently impaired. Suppuration along the thecæ will be followed by contraction of one or more of the fingers from adhesion of the tendons to the sheath.

A proposition has emanated from the American School of Surgery, to treat cases such as indicate a liability to exten-

sive or even destructive inflammation by the operation termed the "Hunterian ligation of arteries"—namely, by putting a ligature on the main artery of the limb between the diseased part and the heart. Dr. Henry F. Campbell, Professor of Anatomy in the New Orleans School of Medicine, and Consulting Surgeon to the Georgia Hospital during the late war, says that in such cases experience very early in the war taught that the risk of hemorrhage by the recurrent circulation was not to be weighed against the great advantage of curing, or at least controlling, the inflammation—indeed, saving the limb and life by the ligation of the main arterial trunk which supported this inflammation. Although the trials of this operation were first made in cases of gunshot injury, yet Dr. Campbell raises the question whether the principle be not one of much wider extension and adaptation. He affirms that no hand, wrist, forearm or elbow, no foot, ankle, leg, or knee, should ever be amputated for excessive or destructive inflammation, especially those cases resulting from traumatic causes, without the surgeon first resorting, whenever the state of the patient will admit of it, to a previous experimental ligation of the artery supplying the affected region. The simpler method proposed by Vanzetti in 1867[1] and by Nélaton[2] of treating cases of severe inflammation by digital compression of the main artery, merits yet stricter investigation. Both surgeons have reported favorable cases, especially the former, who noticed marked local and general improvement after twenty-four hours' compression. Neudorfer[3] warmly recommends the practice as moreover diminishing in many cases the very copious secretions. Mr. Moore, of the Middlesex Hospital, has successfully treated a case by acupressure; and Mr. Maunder, in a letter to the British Medical Journal, 1868, speaks as follows: "Twelve months ago I proposed the application of a ligature to the superficial femoral artery to check acute inflammation of the limb following wound of the knee-joint. The operation was performed with immediate and continuous benefit, and the patient recovered. I need scarcely say that at the time I believed the suggestion to be original, and have only now been undeceived by the perusal of a short paper upon the subject in the American Journal of Medical Sciences of April, 1868. It thus appears that the femoral artery was ligatured first, for wound of the knee-joint, by H. U. Onderdonk, M.D., in the year 1813, and occasionally since that date also in America."

Mr. Lister, who is a great advocate for the exclusion of air from the cavity of an abscess, and of guarding against the absorption of septic material, employs carbolic or phenic acid—a volatile organic compound which, he says, appears to exercise a peculiarly destructive influence upon low forms of life, and hence is a most powerful antiseptic. He states that the results of his treatment in the case of abscesses have been extremely satisfactory, and in beautiful harmony with the principle indicated. The pyogenic membrane, like the granulations of a sore, forms pus, not from any inherent disposition to do so, but only because it is subjected to some preternatural stimulation. In an ordinary abscess the stimulus which maintains the suppuration is derived from the presence of pent-up pus. When a free opening is made in the ordinary way this stimulus is got rid of; but the atmosphere gaining access to its contents, the potent stimulus of decomposition comes into operation, and pus is generated in greater abundance than before. When, however, the evacuation is effected on the antiseptic principle, the pyogenic membrane, freed from the influence of the former stimulus without the substitution of a new one, ceases to suppurate, and furnishing only a trifling amount of clear serum, rapidly contracts and coalesces; at the same time the usual constitutional symptoms are got rid of without the slightest risk of irritative fever or hectic.

In the unopened abscess there are no septic organisms, except in very rare cases. All, therefore, that is requisite is to guard against the introduction of living atmospheric germs, at the time that free opportunity is afforded for the escape of discharge from within. A piece of rag, dipped in a solution of carbolic acid and oil, serves as an antiseptic curtain, under cover of which the abscess is evacuated by free incision. Over this is laid the antiseptic paste,[1] to guard against decomposition occurring in the stream of pus that flows out beneath it; the dressings are changed daily till the sinus has closed.

It is premature to speak decisively either as to the truth of the theory on which this plan of treatment depends, or on the success which may follow it.

[Whatever difference of opinion may still exist as to the truth of the theory upon which the antiseptic system is based,

[1] Gaz. des Hôp., 1867, p. 545.
[2] Ibid., p. 114.
[3] Lancet, Dec. 7, 1867.

[1] The antiseptic paste is made of common whiting (carbonate of lime), mixed with a solution of one part of carbolic acid in four parts of boiled linseed oil, so as to form a firm putty.

there can be no question as to the success that has attended such dressing. The "antiseptic curtain" and "paste" were nearly a dozen years ago abandoned for the "spray," "gauze," "protection," and carbolized drainage-tube. For the method of preparing and applying these antiseptic materials the reader is referred to the chapter on "Antiseptic Surgery."]

On various methods of opening an abscess. The employment of small knives, not unlike those used for the subcutaneous division of tendons, has been strongly recommended by some surgeons for the purpose of opening abscesses. It has been urged that a minute aperture relieves tension, and allows the escape of the matter as satisfactorily as a larger one. The plan has been recommended in cases of suppuration in the thecæ of tendons, of psoas or lumbar abscess, of mammary abscess, etc. I am not in favor of the proceeding, regarding it as generally insufficient. In some cases, where it is desirable to secure the complete evacuation of the cyst, a trocar and canula may be employed; but this measure does not offer any advantages over the common incision, while the canula is apt to become clogged by some of the thick matter which is often found floating in the midst of the pus. It received the sanction, however, of the late Mr. Vincent. If it were very desirable to evacuate the contents of a large abscess without admitting air into the cyst, the surgeon might accomplish his purpose with "Thompson's trocar,"[1] which provides for the escape of the pus through an elastic tube fitted to the under part of the canula. It is an error, however, to suppose that the admixture of air with the pus is the great danger to be apprehended, or that exploring needles and small canulas may be used with impunity in all cases. Many large abscesses, freely opened, continue to discharge healthy matter for many weeks; while the introduction of a small needle has been followed by inflammation of the cyst of the abscess, and general constitutional disturbance. In opening chronic abscesses, a valvular incision is recommended. This may be effected either by passing the knife obliquely, or by drawing the skin in such a way that when it resumes its normal station the opening made through it does not correspond with the opening in the cyst. To such a proceeding there can be no objection, especially when it is wished, as in cases of lumbar abscess, to let out some of the matter, and then to close the opening with adhesive plaster. A method recommended and practised by some surgeons, namely, to pass a long narrow knife through the skin at a little distance from the abscess, and then under the skin into the sac, so that the pus may pass through a subcutaneous canal that shall be perfectly valvular and exclude the air, finds favor in modern works. The proceeding is harmless, provided there be a sufficient aperture for the escape of the pus; but I am not aware that it possesses any real advantages over the usual method. The destruction of a portion of the skin with caustics, such as potassa fusa, or potassa cum calce, is generally objectionable, inasmuch as it inflicts on the patient needless pain without any corresponding advantage. The part is first covered with a piece of adhesive plaster, which has a portion cut out exactly of the same figure and size as the opening intended to be made in the abscess. The best way of making the eschar is to moisten the surface, and to rub the caustic on the part till the skin becomes brown. The active substance is then to be immediately washed off with some wet tow, the plaster is to be removed, and an emollient poultice applied.

The practice of opening an abscess by a seton needle, and of leaving in the silk, that the matter may drain away, is in every respect objectionable; the opening is of necessity small, and the presence of a foreign body dangerous. And the latter objection holds good with regard to the drainage-tubes recommended by M. Chassaignac, and now so universally popular. If a proper opening be made, there can be rarely any occasion for a drainage-tube; and however carefully it is inserted, it must of necessity inconvenience and distress the patient. I have tried this plan, and seen it tried, in cases of empyema. The irritation excited was considerable, and the pus did not always flow out through the tube.

[The use of elastic tubing or some equivalent such as catgut or horsehair is still "universally popular," and likely to remain so, thorough drainage being recognized as a very essential, if not the most essential element in the successful treatment of deep wounds and abscesses.]

Injections of bromine or iodine have been employed with advantage in cases of chronic abscess; they seem to check the secretion of pus by changing the action of the vessels on the cyst-wall. Inflammation is not a necessary result. The abscess should not be complicated with any deep-seated source of irritation, such as disease of the bone. The strength of the injection is usually one part of the tincture to seven or five of water. I think, however, that the practice, once much extolled, has become very limited; those cases being best suited for it which do very well when treated on the usual plan.

[1] Invented by Mr. Thompson, Surgeon, of Westerham.

[Excellent results have followed the method of treatment introduced by the late Mr. Callender, the so-called "hyperdistension;" the sac of the abscess, after being emptied in the ordinary way, being refilled and distended as much as possible with an injected carbolic solution, one part to thirty, which is then allowed to flow off; such overfilling and emptying being repeated until the injected fluid "runs clear from the wound." This method is well adapted to the treatment of chronic abscesses, but the best results have followed its employment in cases of acute abscess also.]

The odor of pus may be so faint as to be scarcely perceptible, or fetid in the highest degree. The fetid odor may continue after the opening of the abscess, or cease in the course of a day or two. In other instances the pus seems to undergo a process of decomposition, and to acquire a fetid smell from exposure to air. With these different points the surgeon should be acquainted, that he may employ such remedies as the charcoal poultice, chloride of lime, Condy's fluid, carbolic acid, etc., to correct the effects on the atmosphere which the patient must of necessity breathe.

SINUS AND FISTULA.

By Sir James Paget, F.R.S.

Revised by P. S. Conner, M.D.

Fistula and Sinus, terms of nearly similar meaning, are the surgical names of (1) long, narrow, suppurating canals (*e. g.*, fistula in ano, mammary sinus, etc.); (2) canals giving unnatural exit to secretions (*e. g.*, gastric fistula, biliary fistula); and (3) unnatural apertures of communication between mucous canals or cavities (*e. g.*, vesico-vaginal fistula). If a distinction is to be made between the terms, *fistula* should be applied to the second and third of the above-named three forms of disease, and to those examples of the first form in which the suppurating canal has two openings; and *sinus* should be applied exclusively to those of the first form in which the canal has but one opening. In these meanings the two names will be here used, although the diseases to which they are applied have so many things in common that it is advisable to consider them under one heading.

If we except the fistulæ, or fistulous openings, that are formed by direct communication of two closely-adjacent canals, as the vesico-vaginal, or the vagino-rectal, the most general characters of fistulæ and sinuses are, that they are canals of much less width than length, lined with ill-formed granulations, discharging a diseased purulent fluid. The canal may be of equal width throughout, as in many perineal and anal fistulæ; or, being narrow at one end, it may at the other dilate into a large cavity, as in many cases of sinus in the breast or the subcutaneous tissue. No general account can be given of the length, or direction, or branchings of such canals; in all these respects there are multiform varieties. So, of their number in any part: one is more common than two or more; but ten, or perhaps more, may exist, as in the worst cases of urinary fistulæ.

In structure, the walls of fistulæ and sinuses differ according to their duration and many other circumstances. When they have existed long, *e. g.*, for one or more years, and are not inflamed, the walls are commonly hard, "callous," not highly sensitive or easily bleeding, and formed of condensed connective-tissue, inseparable from the adjacent structures. In the more recent states, the walls are soft, like ordinary layers of recent granulations, sensitive, readily bleeding, and easily broken through. In diseased states, they may be, as the surfaces of ulcers may be, inflamed, spongy or œdematous, exquisitely sensitive, or sloughing.

In correspondence with these differences in the obvious characters of the walls of fistulæ and sinuses, the granulations lining them are various. In old cases, they are dense and firm, smooth on their free surface, with scarcely a trace of granular or papillary arrangement. In recent cases they are often coarsely granular, dusky, and soft. In all cases, they are unhealthy, having little or none of that tendency to

mutual union, or the development of cuticle, which belongs to the typical granulations of healing wounds and ulcers. And this unhealthiness may be traced in their minute structure; for, of the granulation-cells, few show marks of healthy development, and many are granular, or filled with fatty particles, or not distinguishable from pus-cells, or imbedded in molecular débris-like substance.

The pus agrees with this character of the granulations. It is never like that of a healing wound (the type of good pus) unless the fistula or sinus be healing; but is thin, watery, turbid, or flocculent. Moreover, it may be mixed with the secretions of the part into which the fistula opens—as urine, fecal matter, saliva, etc.

The *orifices of fistulæ*, by their varieties, determine certain designations. If there be two, the fistula (or sinus, as some would still name it) is called complete or open; if only one, incomplete, closed, blind, or occult; if the one orifice open through integument, the fistula is called external; if into a mucous cavity or canal, internal.

The external or integumental orifice is commonly very small; so small that it often closes, or is covered with a thin scab, till discharge accumulating beneath breaks it open again. Often, when the walls of the canal are soft and œdematous, as in cases of abiding irritation from a foreign body, or from dead or diseased bone, a small lobe of soft granulations—vulgarly, proud flesh—projects at and conceals the orifice, or elevates it above the surrounding skin. In very chronic cases, the outer orifice is often depressed in hard and thickened integument, and is like a hole in a scar; in some more recent cases, especially near the anus, it is wide and with compressed margins, like those of the Eustachian tube.

The internal orifice has fewer varieties. It may be, or form part of, a deep ulcer of mucous membrane; but, more commonly, it is a simple round opening, through apparently healthy membrane, level with or slightly upraised from the surrounding surface.

The structures through which a fistula or sinus passes may, in recent cases, be little changed; in old cases they are usually hardened just round it; and where repeated suppurations have taken place, forming new canals or branches of those already existing, it is common to find all the adjacent structures confused in a hard, brawny, sodden substance, covered with coarse granular or almost warty skin. Such is the state in many of the worst old cases of perineal and rectal fistulæ. Where sinuses extend into bone, the immediately surrounding bone is, in recent cases, usually soft or not obviously changed in structure; but in those of long standing it is commonly solidified and hardened, forming a kind of compact osseous canal or cavity lined with a firm, smooth layer of granulations.

The foregoing account relates exclusively to the fistulæ and sinuses that open through either the integument or a mucous surface, or through both. When a fistula is a communication between two mucous cavities or canals, as in the vesico-vaginal, recto-urethral, and others of the like kind, the state of parts may be similar to any of those just described, if the origin of the fistula were in suppuration between the two cavities. But if its origin were in sloughing, or violence, or wound, the fistula is more commonly like a simple short canal or aperture between the two cavities, and the boundaries of the aperture are not granulating or suppurating surfaces, but like healing or healed wounds. In the latter case the edges of the aperture are scarred, and the respective mucous membranes of the two cavities are continuous over them.

The modes of formation of fistulæ and sinuses are numerous, but may be referred to three chief divisions, as dependent on abscess, wound, or gangrene and ulceration.[1]

Abscess is by far the most frequent origin of these diseases. The simplest cases of sinus (or incomplete fistulæ) are those in which an abscess, with a comparatively large cavity formed in loose tissue, has an opening too small for the discharge of its contents. The chances of such an abscess becoming sinuous, through defect of healing, are increased if a great part of its cavity is below its opening and is "bagging," or if the cavity is deep, and the opening traverses textures of various densities, as muscle, or tough fascia, or the mammary gland. In these cases, which include a great proportion of the sinuses extending under muscles, as the orbicularis, glutei, and rectus abdominis, or under fasciæ, as those in the calf and thigh and pelvis, the hindrances to healing are chiefly mechanical. The pus cannot get away so fast as it is formed, and it not only keeps the walls of the abscess apart, but irritates and presses them till, even though they may be very nearly in contact, they will not cicatrize or unite.

The tendency of an abscess to become sinuous through mechanical hindrances to healing is greatly increased by coincident disease, whether constitutional or local. Hence the greater frequency of sinuses after chronic than after acute abscesses, because the former generally oc-

[1] Congenital fistulæ, such as the branchial, urachal, and others, are not considered here. We know their anatomical, but not usually their pathological, origin.

cur in those of defective health; and hence, in part, the frequency of rectal fistula in the phthisical. In like manner, fistulæ and sinuses are especially likely to remain after suppuration in strumous inguinal and cervical lymph-glands, or in a strumous testicle, or in the tissue about a diseased rectum, vagina, or urethra.

Another group of cases of sinuses (or incomplete fistulæ) are to be referred to the formation of abscesses in connection with the presence of foreign bodies or some abiding irritation, as dead or diseased bone or tooth. Such are the sinuses connected with necrosis, caries, diseased joint; the so-called dental fistula, leading to a dead or diseased tooth-fang; the sinuses leading to bullets or other foreign bodies.

Abscess is, again, the most frequent origin of complete fistula. Thus, an abscess forming in the neighborhood of the rectum, after burrowing in the soft adjacent tissue till it nearly lays bare the wall of the bowel, may open or be opened through the integument by the anus. At any time after its discharge, but usually soon after, ulceration through the bared and thinned wall of the rectum forms its second or internal opening, and the contracting abscess becomes a fistula. So, a perineal abscess may first discharge through the integument and then open into the urethra. But in either situation the course of events may be other than this, *i. e.*, an abscess may open, first into the mucous canal, and then through the integument; or ulceration from within the mucous canal may penetrate its wall, and give rise to the formation of an abscess external to it, which may then open through the integument, and thus finish what is requisite for a complete fistula.

In an old case of fistula it may be impossible to determine in which of the three modes of formation just indicated it had its origin, for the result is in all the same. But the observation of cases in process of formation makes it certain that the order of events may be thus threefold; and proves that there is a remarkable liability both to the formation of abscess in the immediate vicinity of disease in a mucous canal, and to the penetration of the walls of the canal by ulceration extending from a discharged abscess. And the liability is not exhausted by the formation and discharge of a single abscess; for it is to the repetition of similar events that we must ascribe the multiplication of branches and new tracks of fistulæ, which are so frequent in the neighborhood of diseases of the rectum, urethra, and other canals and cavities.

Wounds may be the origins of sinuses and fistulæ, in the simplest manner, when they pass, with long or tortuous tracks, through many structures, and do not quickly heal. Thus, gunshot wounds may become sinuous, even though no foreign bodies remain in them; and parts of the wounds of stumps that have become indurated may, without death or disease of the bone, remain unhealed though contracted into the shape of canals. But with much greater frequency wounds lead to the formation of fistulæ when they penetrate mucous cavities or canals, and give exit to secretions, such as urine or saliva. The chance of their doing so is greatly increased when the secretion can escape through them more easily than through its natural passage. Thus a cut into a healthy urethra is, on the whole, rarely followed by urinary fistula; but a cut into one behind a stricture seldom fails to become fistulous unless the stricture be cured. In like manner, the opening of tracheotomy often fails of healing when the operation has been performed for disease leading to contraction of the glottis; for the artificial opening will give easier passage to the air than the natural one.

Ulceration and sloughing may in many evident ways give rise to fistula. As already mentioned, ulceration through the wall of the rectum may lead to abscess external to it, and the abscess may open through the skin; or ulceration behind or through a stricture of the urethra may lead to urinary abscess and fistula. But without abscess-formation, a sloughing or phagedænic ulceration, or a spreading gangrene, may lay open the urethra or any other canal or cavity, and the opening may become fistulous. Cancerous ulceration is a frequent cause of fistulous communications between the bladder and vagina, or vagina and rectum, or other adjacent canals; and sloughing of the walls of the vagina and bladder is the most frequent cause of the vesico-vaginal fistulæ after tedious parturition.

The general pathology of fistulæ and sinuses which is here recorded will receive full illustration in later portions of the work, in the essays relating to diseases of particular organs, as the rectum, urethra, etc. In them, also, the several methods of treatment appropriate to the disease in each locality will be described. Here only the general methods and principles of treatment will be considered.

The methods of treatment may be thus enumerated: general improvement of the health; removal of foreign bodies or occasional irritants; pressure; drainage; injection; seton; cautery; laying-open; tent; plastic operation.

General improvement of the health may be necessary for the healing of any fistula or sinus, but chiefly it is so for those which follow chronic abscess connected

with a strumous constitution, or which remain in the incomplete healing of deep abscesses or wounds, as of stumps. Many such an one, after remaining long unchanging in a hospital, has healed in open air; or, in an ill-fed patient, has healed with good food. The general condition of the health is always to be looked to; but the special means of remedying its defect (if any exist) must be determined for each case separately.

The *removal of foreign bodies*, or of occasional irritants, such as excretions when they flow over fistulæ, is an obvious remedy. But it is not always sufficient; for the walls of the fistula may have become so diseased that the removal of the original cause of its formation may leave them too unsound for healing. These, however, are only occasionally disappointing exceptions to the rule that the removal of a foreign body, *e. g.*, of a piece of dead bone, a bullet, a ligature, a dead or diseased tooth, or any other, is followed by the healing of any sinus or fistula connected with it. Similarly, healing generally follows when, for example, in a recent case of urinary perineal fistula, the passage of urine by the urethra is made so completely free that none passes the wrong way, or when, in an older case, all the urine is withdrawn with a catheter.

Pressure is seldom effectual for the cure of any fistula or sinus, except those that are recent and subcutaneous, or in a part which can be very uniformly compressed against an unyielding surface, as the mammary gland. In these, or in stumps, it may often be used with good effect; but in older, deeper, and more complicated cases, it is scarcely worth trial.

Drainage,— for which the perforated caoutchouc tube of M. Chassaignac is a very happy invention, and the spiral wire tube of Mr. Robert Ellis[1] is better—is applicable to a great number of cases; but chiefly to those in which a sinus or incomplete fistula depends mainly on pus collecting at a level below or distant from the aperture of discharge, or, more generally, when pus is apt to be retained. Numerous instances of suppurating tracks about diseased joints, or following chronic abscesses, or lying deep in a limb or mammary gland, or in the course of suppurating lymph-glands, are of this kind. In some of these cases it is sufficient to make a counter-opening, through which the pus may, by its own weight, flow away; but when this is insufficient, a drainage-tube should be inserted in the whole length of the canal, for the sake of its use in both securing the exit of pus and acting as a seton.

[In the treatment of "suppurating tracks about diseased joints," especially the ankle, Dr. Sayre has strongly recommended the use of an oakum seton as "it is elastic and makes an equable pressure, and at the same time is always pervious to the escape of pus." The same surgeon has found it advantageous to saturate the seton with Peruvian balsam.]

Injection of stimulant fluids is chiefly useful for long sinuses of old standing, running deep, and where counter openings cannot be safely made. Such are many of those that follow pelvic abscess, or lumbar or iliac abscess, not connected with diseased bone (for where bone is diseased, injection is very rarely useful). It may be used also with success in sinuses leading into diseased lymph-glands. The best materials are, the compound tincture of iodine; or solutions of iodine in water, in the proportion of from 5 to 10 grains of iodine, and 10 to 20 grains of iodide of potassium to the ounce of water; or carbolic acid more or less diluted.

Setons may find their use in many of the same cases as drainage-tubes, but are seldom preferable to them, since the tubes not only act as setons, but secure the discharge of pus with more freedom and cleanliness than any other kind of seton can. In some fistulæ, however, in which the track is too small for a drainage-tube, a seton of one or more wires or silk threads may be usefully employed to vivify the granulating walls and bring them to coalescence.

Cautery, actual or potential, and especially the galvanic cautery, is of great value in two classes of cases; namely (1) in the short canals or mere apertures of communication between adjacent mucous cavities, as the vesico-vaginal and others; (2) in the old long and narrow fistulæ leading into the urethra or rectum or salivary duct. Among the former, those which are small and recent, or such as remain after a nearly successful plastic operation, are especially suited for the cautery, which acts by gradually contracting and finally closing the apertures by repeated scarring.

Laying open is one of the most generally applicable methods of treatment of nearly all sinuses and fistulæ. As examples, the cutting up of long sinuses in strumous inguinal glands, and the ordinary operation for fistula in ano, may be

[1] These drainage-tubes consist of a spiral coil of very fine hard brass wire. They are easily made of any required length or size by rolling the wire over a fine steel rod, either by hand, or better, by means of an ordinary lathe. If necessary, they are quickly electro-gilt by a solution of cyanide of gold. They are introduced by an ordinary director, and retained in place by a strip of plaster. A more detailed account will be found in the Lancet for 1869.

cited. The principle of all such proceedings is, to expose the whole extent of the suppurating canal or cavity sufficiently to permit its being "dressed from the bottom," *i. e.*, covered with lint or other material, prevented from closing, and permitted to heal by its own scarring and by the levelling of its borders.

A process, essentially similar to this, but rarely preferable to it, is that of slowly dividing the parts over or inclosing a fistula by gradually tightening a wire or cord passed through it. As the parts inclosed within the loop thus formed are gradually divided, so those without or beyond the loop are gradually healed, being made to granulate directly after they are divided by the loop.

[If the ligature is employed (and in many cases of long deep sinuses and fistulæ it is safer than the knife) the elastic ligature of Dittel is much to be preferred, as it cuts through more quickly, and, because of its elasticity, tightens itself.]

In some cases it is necessary not only to lay open the sinus or fistula, but to destroy its walls with caustic, or by cutting or scraping. It is so in some old callous fistulæ in the soft parts, and more generally in those of bones, or in those that lead down to diseased, though not dead, bone.

When excretions, as urine, pass through fistulæ, neither laying open nor any other proceeding is likely to be useful, unless free passage is provided for the excretion by its natural means of escape.

Tents and the like means for gradually widening fistulous passages may be sometimes preferable to the quicker widening by cutting; but they are rarely used, probably because they are comparatively tedious.

Plastic operations are adapted almost exclusively for such short fistulous canals and apertures as the vesico-vaginal, vagino-rectal, and others that follow violence or sloughing. For the larger apertures of this kind such operations are the only useful means.

GANGRENE.

By Holmes Coote, Esq.

Revised by P. S. Conner, M.D.

By the term "mortification" is meant the death of any portion of the living body. Gangrene may be said to imply a spreading destructive process, attended by progressive loss of vitality in the living tissues, of which sloughing phagedæna, or hospital gangrene, offers a good example. When soft parts are dead, they are said to be in a state of sphacelus. A more limited dead portion of the body is "a slough." Death of bone is termed necrosis; the dead piece a sequestrum; the process by which the dead bone is separated from the living is called exfoliation. Some authors apply the term "necrosis" to death of any tissue; others extend it from bone to death of cartilage only. The modern views of the life of the blood have given rise to the term "necræmia," or death of the blood. But these different terms have been used loosely, and it would lead to no practical result to attempt any very strict definition. When the destructive process goes on internally and in parts concealed from view, such as the lung, the liver, or any similar structure, we say that gangrene is going on in the organ—that its tissue is "breaking down." A separated and ejected portion is a slough. In these cases, although we judge of what is taking place by symptoms only, we employ the same terms as are applied to gangrene and mortification of external parts.

Pathologically speaking, it is true that what is ejected from the tissues in the ulcerative process is dead; but so long as it is in the form of minute particles, visible only with the microscope, we speak of the disease as ulceration, not sloughing or mortification. The two processes are, however, often mingled; a familiar illustration being afforded by sloughing phagedæna, a disease at one time not uncommon in the venereal wards of the London hospitals. Here the ulcerative process proceeds with such rapidity that there is no time for molecular disintegration of the diseased tissues; the ulcerative and sloughing processes go on, as it were, hand in hand. There are also cases of syphilitic ulceration, accompanied by

death or mortification of a circular portion of the integument and the subjacent areolar tissue; and Dr. Baly has noticed, in his observations on dysentery, how even the smallest and most superficial ulcers of the intestine are preceded by the death and detachment of portions of the mucous membrane with its covering of basement membrane and epithelium.[1] Still, surgically speaking, there is a wide difference between ulceration and mortification. A man suffering from an irregular and large syphilitic ulcer of the penis may pursue his avocations and indulge in his usual diet; but when once a portion of the organ perishes or sloughs, small as is the part affected, the pulse rapidly sinks, the extremities become cold, the expression of the countenance is anxious, and the muscular strength fails. When a larger portion of the body dies, such as part of a limb, the symptoms are proportionately more severe.

Mortification may proceed from a variety of causes: from local violence; from the application of heat or escharotics; from the action of certain animal poisons, such as the urine or the variolous poison; from inflammation in a part where, to use the language of Hunter, there is no increase of power, but, on the contrary, a diminution of it; from arrest of circulation, or even in some cases, disturbance of it, etc. Two or more of these causes may be combined: mortification may be immediate, or more slow and consequent on other well-marked changes. It may be limited, or may spread; the parts affected may be dry or soft, etc.

We are able to trace in many ways the influence of nerve-force in maintaining the vitality of a part. Suppose a child to have a deformity of a limb, dependent upon abnormal position of the bones, as in club-foot; that limb will attain the same length and admit of development to the same extent as the opposite. Suppose, on the other hand, that the affected limb be suffering from infantile paralysis, referable to change in the great nervous centres; it will be noticed that there is a want of animal heat, a sluggish circulation, defective nutrition, and arrest of growth. A limb so conditioned, when exposed to cold or otherwise injured, is but little able to maintain the processes proper to repair; and although, in many cases of loss of nerve-power, death of the tissues seems to result from their inability to bear ordinary inflammatory disturbance, still there are other cases in which the rapidity of the change from life to death requires another explanation. Such a case, probably, is that related by Sir B. Brodie, who saw mortification of the ankle begin within twenty-four hours after an injury to the spine. But diminution of nerve-power generally leads to impairment of nutrition, and to repeated attacks of low inflammation, during which the tissues may slowly perish. A warder in the Bridewell city prison suffered for many months from agonizing pain in the head; at times he had scarcely command of himself; the pain chiefly seemed to follow the course of the branches of the right superior maxillary nerve, but the other branches of the fifth nerve of the right side were likewise affected. In course of time the cornea of the right eye became opaque, and the conjunctiva red. After some weeks the cornea sloughed, and the humors of the eye escaping, the organ collapsed. The termination of the case was singular. One night, after agonizing pain in the head, something was felt to burst, when a large quantity of thick matter was discharged from the nose; the symptoms subsided, the man regained his usual health, and passed into some other avocation. In the Museum of St. Bartholomew's Hospital (ser. ix. no. 9) is an example of central penetrating ulceration of the cornea, in consequence of destruction of the trunk of the fifth cerebral nerve by the pressure of a tumor near the pons Varolii. The whole nutrition of the corresponding side of the face was impaired; the patient had repeated attacks of erysipelatous inflammation, bleeding from the nose, and at length destructive inflammation of the tunics of the eye, and ulceration of the cornea.

[Impairment or even complete loss of sensibility of the part supplied by the first and second branches of the fifth pair of nerves, may exist for a long time without any ulceration of the cornea taking place; indeed it is probable that when such corneal trouble occurs it is usually only indirectly consequent upon the nerve-affection, injuries not being felt and the presence of local irritants not being recognized.]

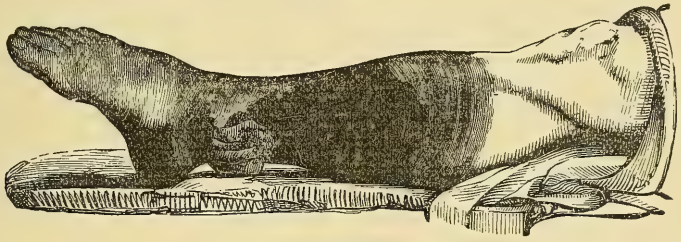
Parts die through a deficient supply of blood, and this may be the sole cause, as when mortification follows the application of a ligature to the main artery of a limb, or the sudden laceration of the same vessel by violence; or it may be combined with diminished nerve-power, as in some cases of gangræna senilis. When death of a part takes place rapidly, the vessels still contain blood and the usual fluids, and the mortified parts are moist and soft. When, on the other hand, the death is slower, there is usually a deficiency of supply of blood; the vessels become empty, and the part hardens and withers. And hence we read of moist or acute, and of dry or chronic gangrene. Exceptions to this law are apparent and not real. When it was

[1] Gulstonian Lectures, in Medical Gazette, 1847.

remarked by Mr. James, "that acute or rapid mortifications are not necessarily humid, as the slough from the application of caustic potash proves,"[1] he should have added that the caustic action of this application consists in the abstraction of the watery elements of the part on which it acts.

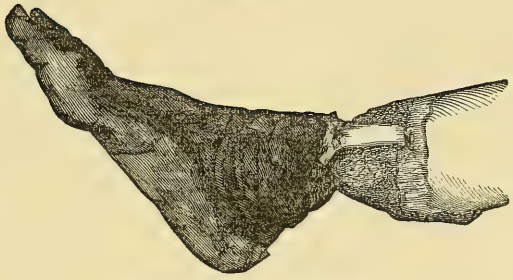
[Fig. 63 shows the swollen condition of a leg affected with moist gangrene following an injury, or the arrest of blood in the vein, as by thrombosis. In Fig. 64 may be seen the withered and shrunken state induced by a stoppage of the arterial current.

Fig. 63.



Moist gangrene.

Fig. 64.



Chronic, or senile dry gangrene.]

Death speedily follows the complete stagnation of blood, as when a part is firmly strangulated. But if there be any circulation, however imperfect or slow, nature struggles for life. The surgeon who undertakes to destroy a vascular nævus, or mother-spot, by the ligature, knows well the importance of using a stout thread and of tying the knot firmly. No half-measures will answer; either the circulation is completely arrested, or the operation is only partially successful. The same effect may be noticed in cases of strangulated hernia: if the strangulation be complete, the part dies at once; but if it be less in degree, the venous circulation is retarded, while the arterial goes on; hence congestion and swelling ensue; inflammation may supervene, or ulceration at the seat of the stricture. It may be questioned, however, whether vitality becomes extinct in any case of this kind until the strangulation is so firm, either directly or from secondary swelling, that complete stagnation of the blood has taken place. I have seen mortification of the whole of a lowly-organized morbid growth in the thigh follow an operation undertaken without success for its extirpation; but here, doubtless, the tumor had been displaced from its connections during the proceedings of the operation, and it perished accordingly.

It is commonly believed that inflammatory congestion is that which most commonly leads to mortification; but in accepting this view we must couple with it a modification, which Mr. Paget thus expresses: "It is perhaps to be regretted that the cases of this class should have been taken as if they were the simplest types of the process of mortification, and that the process should have been studied as an appendage, a so-called termination of inflammation; for, in truth, the death of an inflamed part is a very complex matter; and, in certain examples of it, all the more simple causes of mortification may be involved. Thus inflammatory congestion may end in the stagnation of the blood, and this, as an indirect cause of mortification, may lead to the death of the blood, and to that of the tissues that need moving blood for their support. But a degeneration of the proper textures is a constant part of the inflammatory

[1] On Inflammation, p. 94.

process; and this degeneration may itself proceed to death, while it is concurrent with defects in the condition of nutrition."[1] The formation of bed-sores is referred by the same author to the second of these conditions, for he points out that the intensity of an inflammation is not alone a measure of the probability of mortification ensuing in its course; neither is mere debility, for we daily see inflammation without death of parts in the feeblest patient with phthisis and other diseases. "It is as if the death of the part were the consequence of the defective nutrition, which concurs with the rest of the inflammatory process, being superadded to that previously existing in the part."[2]

Instances of mortification from defective nutrition are illustrated by the examples of sloughing of the cornea in animals fed upon food deficient in nitrogen. And the influence of improper food upon the blood, rendering it unfit to maintain vitality in the remoter parts of the body, is exemplified by the accounts of gangrene affecting the lower extremities in persons eating bread made of bad black wheat or rye. This occurrence has been known to prevail in districts on the Continent, especially after wet seasons, where rye forms a principal article of food. The name applied to the diseased rye is ergot or cockspur rye. The part of the body affected seemed to become insensible, cold, dry, and withered—to undergo those changes to which the term dry gangrene has been applied. Saviard mentions that, in cases noticed at Orleans in 1694, both upper and lower extremities were affected. Noel, who wrote in 1710, states that he had never seen any one of the female sex affected, and that he had only witnessed one case in which the gangrene attacked the upper extremities. According to Bassau, surgeon to the Hospital St. Antoine, Dauphiny, the cases which he saw were not all of the dry kind, the limb sometimes becoming putrid, and maggots being generated.

Cases of mortification from eating unsound wheat have been recorded by Dr. C. Woolaston in the Philosophical Transactions, 1762. But of late years such cases appear to have been rare. The increased facilities of locomotion have proved the means of equalizing in some measure the wants and supplies of mankind, and have tended, by raising the position of the very poor, to improve the general sanitary condition.

When soft parts are about to mortify, the bright red and shining condition of the skin previously existing, becomes of deeper and more livid hue; and here and there patches of dusky brown, green, or blue, mottle the surface. The cuticle becomes loosened, and rises in blisters; the temperature falls; and the discolored parts become cold and insensible. The color of the skin becomes deeper and blacker, a thin, stinking fluid issues from the exposed integuments, and gas is evolved from the decomposition of fluids in the deeper-seated structures.

If a limb which has undergone this change be cut into, the deeper-seated tissues are found to be soft, putrid, and rotten. They are soaked in a thin fetid serum, mixed with bubbles of gas. The color varies from ash-color to brown, but rarely black. The tendons retain much of their normal appearance, except that when handled they are found to be softer than natural.

The appearances presented by mortified intestine, as observed in the operation for strangulated hernia, differ but slightly from the above. The surface of the gut loses its smooth, bright aspect, although the vessels remain congested and the part is black. But on this black surface the death of the tissues is marked by ash-colored spots of various shapes and sizes, which in some instances map out the surface of the congested intestine. The same thin, stinking fluid exudes, and frequently fills the hernial sac; while the effects of this change are indicated externally by the deeper and more livid color of the skin, and its yielding and doughy feel to the touch.

We have now to speak of the mode by which, after the cessation of the gangrene, the dead are separated from the living parts. It is but seldom that this process is attended by hemorrhage, for the blood coagulates in the large arteries which lead to a mortified part. "When a gangrened limb," observed Petit, "is cut off in the dead part, no hemorrhage occurs, because the blood is coagulated a great way in the vessels. . . . . We have several examples of limbs amputated on account of gangrene, in which no hemorrhage occurred, although the amputation was made a considerable way in the living parts; because the clot was not confined in these cases to the dead part, but was continued forwards into the living as far as the inflammatory disposition extended."[1] When gangrene stops, the livid color of the adjacent integument, which marks its onward progress, becomes brighter and redder. It is at this part that the so-called ulcerative process begins, constituting the line of demarcation between the dead and living structures. It was at one time believed that this act was accomplished by the ulceration of the por-

[1] Surg. Pathol., vol. i., p. 459.
[2] Op. cit., p. 460.

[1] Mém. de l'Acad. des Sciences, 1732.

tions of the living tissues which are immediately contiguous to the dead; and that the groove, gradually becoming deeper, undermined the mortified parts until they were completely separated. In proportion as the groove deepens, so do granulations rise from the living surface, and pushing, as it were, the slough before them, present upon its removal the aspect of a healthy granulating sore. But in this explanation the ulcerating and granulating processes would seem to proceed at one and the same moment, which is impossible; and perhaps the latter process is of earlier occurrence, and of greater importance in the act of separation than is commonly believed. This possibility of the living tissues acting by absorption on the dead, at one time disbelieved, has now been proved by instances of the absorption of portions of pegs of ivory, driven like nails into bones, to excite inflammation, for the repair of ununited fracture. Such a case occurred under the care of Mr. Stanley, some years ago, and more recently in one treated by myself, where so active was the absorption, the patient being a child, that the pegs dropped out before accomplishing their end, being deprived, as it were, of their fangs. The fact of the upper portion of the peg being untouched, though in contact with the living tissues and imbedded in pus, may be due to a law that the absorbents of bone are required to act upon the osseous tissue. Certain it is that the granulating process seems to be contemporary with the separation of the living from the dead tissues. The superficial slough, formed by the application of strong nitric acid, affords us the opportunity of witnessing this process. When the treatment is employed for stopping spreading gangrene with success, the first local effect after the charring of the sloughing surface is the disappearance of the livid red color of the yet living skin; then, in the course of a few days, the dried slough shrinks and contracts, while from the line between it and the living parts granulations seem to spring in every quarter, and just in proportion to the rapidity of this process of separation are the granulations the more abundant and the secretion of pus copious.

For the phenomena attending exfoliation of bones, see DISEASES OF BONE.

The treatment of mortification is guided by rules which are much simpler than in times gone by. It is true that the surgeon will have to consider whether the form of the disease be acute or chronic, and whether the patient be suffering from pain, fever, and constitutional disturbance; but upon one point he may be sure in every case—namely, that he will have to husband the patient's strength, and to soothe him in all possible ways. The idea of the surgeon "seeking to afford relief by imposing the antiphlogistic regimen," which consists in the employment of "blood-letting, purgatives, diaphoretics, and diluents,"[1] is now regarded as preposterous; and cases are not met with in which "after one bleeding the pulse is quick, hard, and full." Sir Astley Cooper seems to have understood the impropriety of abstracting blood in cases of gangrene, although in courtesy to his provincial brethren he limited his condemnation to London practice. His plan consisted in giving small mercurial doses at night, in order to restore the secretions of the intestinal canal and liver; and the liquor ammoniæ acetatis with a few drops of the tinctura opii, several times a day, with the view of lessening irritability and tranquilizing the system. We may often read an instructive lesson from transitions of opinion. The practice of bleeding, founded on improper principles, was tacitly condemned; and no other course substituted except an attempt to palliate symptoms.

In 1715, Mr. Rushworth, a surgeon of Northampton, published his remarks on the value of Peruvian bark; and the most exaggerated statements of its efficacy were made by its supporters, who affirmed, with a want of judgment equal to that of the supporters of venesection, that it ought to be employed in almost all cases of mortification as soon as the violence of the inflammatory symptoms had been appeased.

More accurate pathological investigation has taught us that, in truth, the means which we possess of controlling gangrene are few in number, although they often require great discrimination in their use. We should never lose sight of the cause of the disease. In an instance related further on, where mortification of the lower extremities resulted from impairment of the heart's action caused by effusion of fluid into the pericardium, the administration of mercurials tended, by suppressing inflammation, to remove the offending cause. When a part has perished in consequence of cold and starvation, warmth and generous diet, administered with prudence, is the course clearly indicated. There are instances in which bark or quinine may be indicated in preference to wine or other stimulants; but in no way do we possess a specific against mortification, either as an external or internal remedy.

Of all medicines which need special notice, opium stands pre-eminent. By its free administration we are enabled to control in some degree the pain which wears out and exhausts the patient. Mr. Pott used

[1] Thompson on Inflammation, p. 559.

to administer one grain every three or four hours; but never less than three or four grains in the twenty-four hours. He recommended it, not as a specific, but, in Mr. Hunter's words, as "a remedy which does good by not letting the disease do harm to the constitution."

The following, then, should be the plan of treatment: If there be heat of skin, combined with feverish symptoms—thirst, loss of appetite, sickness, and rapid pulse—let us remember that this stage will soon pass by and leave the patient in need of all his remaining strength. Let not the surgeon *force* solid food upon the patient against his will; easily-digested food, such as milk, puddings, broth, etc., may be freely offered; port-wine and water, or brandy and soda-water, or effervescing salines, may be prepared as drinks. If ice be grateful to the palate there is no objection to its employment. Pain must be controlled by opium or morphine.

In cases where there is absence of fever, preparations of bark may be given; and of these perhaps the liquor cinchonæ is the best. It may be combined with ammonia, aromatics, chloric ether, camphor, or other similar preparations.

In speaking of local applications, we cannot do better than call to mind the words of Mr. Pott: "Whatever heats, irritates, stimulates, or gives uneasiness, appears to me always to increase the disorder, and to add to the rapidity of its progress. And, on the contrary, I have always found that whatever tended merely to calm, to appease, and to relax, at least retarded the mischief, if it did no more." It is desirable to keep the living parts warm; consequently the limb may be wrapped in cotton-wool or flannel. If the mortified part is dry, no particular local application is needed; but wherever it is moist or emits an unpleasant odor, it may be enveloped in a charcoal poultice, made by mixing powdered charcoal and linseed-meal; or be surrounded by muslin bags filled with finely-broken wood-charcoal, or folded cloths soaked in Condy's fluid or carbolic acid and oil. Stimulating applications, such as brandy, balsams, or resins, are usually worse than useless.

[Immersion of the gangrenous part in hot water frequently changed, or, better, kept steadily flowing into and out of the receiving vessel, produces an excellent result, both as respects the comfort of the patient and the arrestation of the morbid action (F. H. Hamilton). Baths of chloral solution (1-1000 or 1-500) and oxygen baths have been frequently and advantageously employed, especially by the French surgeons.]

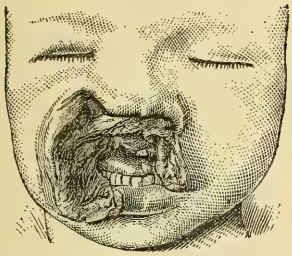
On this head exception is made to the treatment of cases of traumatic gangrene, where immediate amputation, when possible, is indicated; to hospital gangrene, which is treated by the application of powerful escharotics; and to frost-bite; on each of which subjects the treatment is appended to the proper section.

Noma. Among other instances of mortification from defective nutrition is that peculiar affection called Noma, or water-cancer of children; *Wasserkrebs*, water-canker, *cancer aquaticus*. It has been chiefly described by foreign writers. It is spoken of by Galen and Celsus. Battus, a Dutchman, mentions the particulars of the case of a girl, aged five years, who died, and of a boy, aged three years, who recovered. Van Swieten says that he has seen the first set of teeth fall out, and the second set destroyed, the lower jaw-bone exfoliate, the lips, cheeks, tongue, and chin eaten away before the child died. The disease rarely attacks children older than ten or eleven, or younger than one year; and occurs in those of weak frame, improperly and insufficiently nourished. It has been noticed after measles, intermittent, remittent, and other forms of fever. The first symptoms are those of constitutional disturbance, wasting and loss of appetite, followed by swelling of the salivary glands, and a profuse discharge of saliva, which is thin, watery, and fetid, and flows from the mouth involuntarily during sleep. Next, ulceration commences in the gums, which swell, become livid, and separate from the teeth; the teeth become loose, and are soon covered with dirty sordes. Soon ash-colored spots show themselves on the gums and neighboring mucous membrane; they turn to dark-colored sloughy-looking sores, which spread rapidly in every direction, exposing the bone, which subsequently exfoliates. The sore spreads from within outwards, not by ulceration, but by a moist and sometimes dry gangrene, while the parts around swell and become first of livid red hue, then of grayish or black color, marking the spreading gangrene. A large aperture is thus made in the cheek, sometimes separated by a frænum from the mouth, at other times continuous with it.

In other cases the tumefaction of the cheek may be shining and hard, resisting the pressure of the finger; the temperature may be increased, and the color a rose-red fading away at the circumference. After a few days a blue spot appears externally, surrounded by a well-defined red border; the color next changes from blue to black; and the destructive process goes on with such rapidity that in from three to six days the entire cheek has been destroyed. The changes in the bones seem to be peculiar; they are usually confined to the surface lying next

to the layer of softened tissues; the part not in immediate contact being healthy. Two different morbid processes have been noticed. First, the separation of the alveolar process from the portion of diseased bone; secondly, the successive destruction of the remaining surfaces of the bone.

Fig. 65.



Cancrum oris. Model 26⁵, Guy's Hosp. Museum.

The organized constituents take part in the process of softening, the earthy particles being set free; thus in children the separation of the alveolar process is easily affected, while the rest of the bone acquires a more or less worm-eaten appearance when the destructive process goes more deeply. An examination after death shows the sphacelated part of doughy consistence, black and easily torn. Underneath the external gangrenous covering the areolar tissue is greasy and yellow; serous infiltration, also of yellowish color, has taken place around. There is effusion under the arachnoid membrane and in the ventricles of the brain. In one case the heart and lungs were bloodless, and there were tubercles in the substance of the latter. The intestines were adherent, from the effects of previous peritonitis, and the mesenteric glands were swollen. In such a disease the obvious indications are, to remove the patient to pure air, to administer stimulants and proper nourishing diet, and to touch the sloughing parts with a solution of nitrate of silver, or some other stimulating application. There may be cases requiring the use of a strong escharotic. Antiseptics must be freely used.

Traumatic gangrene.—A part may be destroyed by direct local violence. There is no preceding inflammation, nor vascular disturbance of any kind, to account for the change; the immediate effect of the injury has been to deprive the living tissues of their life, when they become subject to the same laws of decomposition as are applicable to the dead animal. As occurring in the lower extremity, the foot becomes cold and pulseless; there is no sensation, even if the part be pricked with a needle or knife; the appearance of the limb may not be much changed, for the skin is elastic and does not lacerate very easily. In 1835, a brewer's servant was riding asleep on the shaft of a dray drawn by a powerful team of horses. In passing through a turnpike the man's legs were jammed between the dray and the gate-post. The patient was immediately brought to the hospital. The right leg was severely injured, but the left appeared simply cold and without sensation: vitality had left it; and after amputation it was found that, although the integument was entire, every tissue had been crushed and divided down to the bone, the popliteal nerve alone retaining its continuity. The same species of accident is that inflicted by cannon-balls or other heavy missiles, by steam-machinery or railway contusions: the part perishes simply because unable to retain the life inherent in it. The cause of death is not from want of blood. Vitality would be equally extinct, were it possible to maintain the circulation artificially.

But the proximity of a mortified part to living tissues cannot be borne with impunity. Nature endeavors to cast off the dead from the living tissues by an inflammatory process in the latter, which speedily lose their vitality from inability to support this action towards repair. According to Hunter, a diminution of power, when joined to an increased action, becomes a cause of mortification, by destroying the balance which ought to subsist between the power and action of every part. Thus the mortification spreads towards the trunk preceded by a blush of dusky red, marking its onward course and illustrating what is called "traumatic gangrene."

It does not often happen that the surgeon witnesses in such cases death from the unchecked progress of the disease. The indications for immediate amputation are so clear and so generally acknowledged, that he who shrinks from the responsibilities of the operation stands exposed to just reproof. A girl once came before my observation in whom the left arm had been crushed by machinery beyond the possibility of repair. Partly yielding to the patient's own strongly expressed wishes, the surgeon did not amputate: mortification took place within a few hours; it spread upwards towards the chest, the tissues about which became infiltrated and swollen by serous exudation, and the patient expired comatose after a period of sufferings of no ordinary character, during which she frequently implored the performance of that operation which, once delayed, was no longer practicable. In the case of a bone, there may be no apparent change of tissue—the part which is dead remains surrounded by, and even attached to, living tissues; but its circu-

lation cannot be restored; and its removal by absorption, at one time thought impossible, is at least so slow a process as rarely to be contemplated by the surgeon in the light of a curative action.

The application of powerful escharotics produces, in the same way as the application of heat, immediate death of a part by chemical decomposition. No inflammatory process is needed to account for the change—the heat and redness which may be noticed in the surrounding tissues being connected with the process of separation of the slough. Let us select as an illustration the action of strong nitric acid upon the living tissues. This escharotic applied to any part of the living body causes immediate decomposition of the different elements, which become oxidized, leaving the carbon of the tissues as an eschar. Experience has shown that, after a part has been thus purposely destroyed, the better mode of treatment consists in leaving the dry eschar exposed to the air, the watery parts having been removed by the acid.

Immediate death of a part may be produced by the extremes of heat and cold; and although it is commonly believed, and may in some instances be the case, that these agents, as well as caustics, applied in smaller measure do not kill the part at once, but excite an inflammation in it, which, added to the damage already received, may lead to indirect or secondary mortification, yet when we try to accomplish this end in practice as a means of cure, we encounter unforeseen difficulty. The injection of nævi, or mother spots, with irritating fluids is an example of what has just been said. I know of no means by which a sufficient amount of inflammation so as to cause death of the part can with certainty be produced; we may destroy the vascular system at once by a powerful caustic, but we cannot always induce secondary mortification. Freezing applications, employed to render a part insensible to the pain of a surgical operation, are not followed by secondary inflammation and mortification, nor has a similar result ensued from the exposure of the body to heat. It is more than probable that, in the healthy subject, the vitality of the different tissues is in little danger from inflammatory disturbance. The death of a part must be effected by powerful agencies coming from without, or by some accidental causes of disturbance to the general health. The only apparent exception to this is in the case of sloughing of tendons or areolar tissue after certain forms of inflammation; but the peculiar character of organization in such structures is a sufficient explanation of this occurrence.

[Under the head of "Traumatic Gangrene" are usually classed not only such cases as above noticed, but all in which the mortification is consequent upon an an injury received, whether the death of the part is produced at once or later.]

Secondary mortification.—It is difficult in all cases to draw the line between immediate and secondary mortification. A boy was under the care of Sir W. Lawrence, in St. Bartholomew's Hospital, to whom mortification of the toes had ensued from his sitting with his feet in the water of a running stream one summer's day after a long walk. We cannot believe that this accident could have happened to a perfectly strong and healthy child; there must have been some cause to render the circulation feeble and the extremities cold. In all probability, the blood never flowed again in its accustomed way through the chilled parts; and the inflammation which surrounded the mortifying structure was, it is true, due to vascular reaction in living tissues, but in no way connected with the spread of the gangrene, the exact extent of which was limited by the accident. In other instances we see a patient of habitually intemperate habits suffering from gangrene of an entire limb; the integument is of livid red color, the countenance sunken and anxious, the pulse rapid and feeble. At one time we accepted the explanation of such cases, that inflammation occurring in a part of low vitality was likely to be followed by gangrene; but more accurate pathological investigation has shown that the main artery of the limb may be plugged,[1] and that causes, either mechanical or vital, may interfere with the establishment of the collateral circulation. Although it is true that the progress of the mortification is marked by low inflammatory action, yet it would be incorrect to regard such inflammation as the cause of death. The part is perishing from insufficient supply of blood; and the vascular excitement, the last expiring flame of vitality, does but influence the course which in each case the peculiar method of disorganization may take.

Hospital gangrene.—Gangrene consequent upon a low type of inflammation requires for its development the exercise of some of those subtle undefined causes which govern the outbreak of epidemics. We apply to it the terms phagedæna gangrænosa, gangræna contagiosa, hospital gangrene, sloughing phagedæna, etc. It is a species of humid gangrene, peculiarly characterized by its contagious and infectious nature. During an outbreak which took place in the year 1846 in St. Bartholomew's Hospital, the extension of the disease in two instances was clearly traced

[1] For further information on this subject, see Diseases of Arteries.

to the use of a sponge which had been first applied to a gangrenous sore, then boiled, and afterwards applied to a healthy wound. The infectious nature of the disease—that is to say, its rapid extension from patient to patient without personal contact in the same room—has been often witnessed. By this term we mean not only to imply that a number of persons living in the same room, breathing the same atmosphere, and exposed to the same causes, suffer in common, but that the exhalation from the wound of a person suffering from hospital gangrene may become in itself the means of the spread of the disease. A lady living in a low but not unhealthy part of the environs of London underwent the operation of extirpation of the breast for cancer. She was of excitable temperament, but healthy-looking and country-bred. About ten days after the operation the wound assumed an unhealthy aspect, and became gangrenous in the space of twenty-four hours. She was restless and irritable, although the pain was not insupportable. A single application of the strong nitric acid sufficed to arrest the sloughing process, and the patient recovered. But the odor clung to the walls of the chamber; and after her removal, and the apparent purification of the apartment, of two persons who consecutively slept there for a night, the first had a sharp feverish attack, attended with total loss of appetite; the second had a sudden attack of diarrhœa. There is every reason to believe that had a patient with an open wound been put there, the healing process would have been arrested.

In contrasting the experience gained in the Peninsular with that obtained during the Crimean war, one cannot fail to be struck with the remarkable rarity of gangrene among the British hospitals in the East. "During the first winter," says Mr. Macleod, "it prevailed a good deal in a mild form at Scutari; but it never became either general or severe. It frequently attacked the openings both of entrance and exit (as applied to gunshot wounds); but occasionally seized on one only, showing apparently a predilection for the wound of exit."[1] Dr. Taylor thought that in India gangrene more commonly appeared in the wounds occasioned by grape or canister. In many cases Mr. Macleod thought the best designation would have been putrid degeneration. "The abominable state in which the barrack-hospital at Scutari was during its early occupation may well have caused an outbreak of hospital gangrene among the broken-down men, who lay so thickly around the doors of the offensive latrines; but I cannot say that I noticed any greater tendency to its appearance at these places than at any other portion of the hospital. The corridors presented, I think, the greatest number of cases. Whenever it appeared, the patients were isolated, and sent into wards set apart for the treatment of the disease."[1] The French, however, suffered most dreadfully from hospital gangrene in its worst form; the great evil appearing to have been "overcrowding." The disease raged rampant in the hospitals on the Bosphorus, and likewise in many of the transports. M. Lallour, surgeon to the Euphrate, says, in his paper on the subject, that from one of their ships sixty bodies were thrown overboard during the passage of thirty-eight hours to the Bosphorus.

There cannot be a doubt, in speaking of the causes which lead to this fearful disease (which rages under certain circumstances thus epidemically), that it is due to the agency of some unknown poison, which finds for itself a soil fit for propagation. Some circumstances, such as overcrowding and bad drainage, promote its rapid increase; but they alone are insufficient to account for all the phenomena.

In the winter of 1846–47, the buildings constituting the north side of the square of St. Bartholomew's Hospital became invaded by the malady now under consideration. A healthy man, aged 32, cut his hand in the palm by accident, December 2. He was put into a light and airy ward, in the next bed to a patient suffering from compound luxation of the radius, attended with symptoms of diffuse inflammation of the areolar tissue. The cut hand swelled, became hot and painful, and a small abscess formed, which was opened by the house-surgeon. The wound thus made sloughed and assumed some of the characters of a phagedænic sore. The man was immediately removed to another part of the hospital, and, after considerable loss of substance, including some of the tendons, the hand ultimately cicatrized, but with impairment of motion. The patient with the dislocated wrist, suffering from diffuse cellular inflammation, died on December 23; and it was found on examination after death, that suppuration attended with sloughing of the tendinous structures existed in both forearms, extending among the muscles under the fascia to near the elbow-joint. From this time a succession of cases of well-marked hospital gangrene ensued, the particulars of which, read before the Medico-Chirurgical Society, were published in the Lancet, 1857. It was argued, from the circumstances attending a similar outbreak in University College Hospital, that the disease was apt to occur in new buildings, that in which it was first noticed at St. Bartholomew's Hospital being quite of recent date. But in op-

[1] Surgery of the Crimean War, p. 165.

[1] Op. cit., p. 166.

position to this view, there were at the same time cases in one of the older parts of the hospital quite detached from the preceding, but presenting the same aspect to the north. Now in that year there had been striking thermometrical changes from unseasonable heat to extreme cold, and it is remarkable that when the disease prevailed in the Crimea there blew that much dreaded wind, the oppressive sirocco. "In the Crimea," says Mr. Macleod, "during the heat of the summer of 1855, after the taking of the Quarries, and the assault on the great Redan in June, not a few amputations of the thigh were lost from moist gangrene of a most rapid and fatal form. In the case of a few, who lived long enough for the full development of the disease, gangrene in its most marked features became established; but most of the men expired previous to any sphacelus of the parts, overwhelmed by the violent poison which seemed to pervade and destroy the whole economy. This form of the disease occurred in four cases under my own charge, in men who had had a limb utterly destroyed by round shot or grape. In all, the knee-joints were crushed; the collapse was deep and prolonged; and the operation performed primarily in the middle third of the thigh. Three of the four were of very intemperate habits. All these cases took place about the same time, at midsummer, when many other similar cases appeared in camp. The wards, though full, were not overcrowded, and could from their construction be freely ventilated. The weather was sultry, and the cholera was in camp. The atmosphere was charged with electricity, and the dreaded sirocco prevailed. Wounds generally assumed an unhealthy aspect for days when this pestilential wind blew. The cases of all those who died in my wards seemed to be doing perfectly well up to sixteen hours, at the furthest, before death."[1]

The statement of Mr. Blackadder,[1] that hospital gangrene is at first a purely local affection, and that the constitutional symptoms do not make their appearance before the third or fourth, sometimes not till the twentieth day, is quite at variance with present experience. In St. Bartholomew's Hospital patients complained of pain and tightness across the forehead, accompanied with severe headache; the pulse was small, quick, and thready; the aspect of the countenance anxious and depressed; and they were very commonly irritable. There was from the first a stinging pain in the wound, which prevented sleep. So constant were these symptoms that the surgeon could predicate the outbreak of the disease in particular cases. Now what says Mr. Macleod?

[1] Surgery of the Crimean War, p. 168.

[2] Observations on Phagedæna gangrænosa, by H. Home Blackadder, 1818.

"In recording one case I relate all. During the night previous to death, the patient was restless, but did not complain of any particular uneasiness. At the morning visit, the expression seemed unaccountably anxious, and the pulse was slightly raised. The skin was moist and the tongue clean. By this time the stump felt, as the patient expressed it, heavy like lead, and a burning, stinging pain had began to shoot through it. On removing the dressings, the stump was found slightly swollen and hard, and the discharge had become thin, gleety, colored with blood, and having masses like gruel occasionally mixed with it. A few hours afterwards the limb would be greatly swollen, the skin tense and white, and marked along its edge by prominent blue veins. The cut edges of the stump looked like pork. Acute pain was felt."[1] Mr. Macleod here says, "The constitution by this time had begun to sympathize." Surely he has shown by his own words a sufficient amount already of serious general disturbance. The cold sweat which broke out over the body; the irritable stomach; and the weak, frequent, and failing pulse, were but indications of approaching dissolution. The respiration became short and hurried, giving evidence of the great oppression of which the patient so much complained. The heart's action gradually and surely got weaker, till, from fourteen to sixteen hours from the first bad symptom, death relieved him of his sufferings. Post-mortem examination, instituted shortly after death, showed the tissues of the limbs, and in many cases those of the internal organs also, to be filled with gas, and loaded with serous fluid. The vessels leading from the stump were healthy, and in only one case had there been any actual mortification previous to death. After the taking of Sebastopol in September, the same form of disease again appeared, especially among the Russians who had been operated on, and was so deadly, that "in no case which I could hear of did recovery follow."[2] Dr. Hennen's account of hospital gangrene as it occurred in the Peninsula, during the war with the French, corresponds in all essential particulars with the above. "Let us suppose that our wounded have all been going on well for several days, when suddenly one of our most promising patients complains of severe pain in his head and eyes, a particular tightness about the forehead, loss of sleep, and want of appetite; and that these feelings are accompanied with quickness of pulse and other symptoms of fever; his wound, which had been healthy and granulating, at once becomes tumid, dry, and painful, losing its florid color, and assuming a dry and glossy coat. This is a description of the first stage of our Bilboa hospital gangrene. If this incipient stage were overlooked, the febrile symptoms soon became aggravated; the skin around the sore assumed a higher florid color, which shortly became darker, then bluish, and at last black, with a disposition to vesicate, whilst the rest of

[1] Op. cit., p. 170. [2] Ibid., p. 171.

the limb betrayed a tendency to œdema. All these threatening appearances occurred within twenty-four hours; and at this period the wound, whatever might have been its original shape, soon assumed the circular form. The sore now acquired hard, prominent, rugged edges, giving it a cup-like appearance, with particular points of the lip of a dirt-yellow hue; while the bottom of the cavity was lined with a flabby blackish slough. The discharge in this second stage became dark-colored and fetid, and the pain extremely poignant.[1]

There is no reason to believe that the disease, as witnessed now, differs in any essential particulars from that recorded by the surgeons of the Peninsular war; and a careful examination of facts shows, I think, conclusively that the causes which lead to its outbreak are general and not local, and in most instances preventible. A case came before my observation in which spreading gangrene of the character here described took place on the nates of a young married woman. She had been travelling outside a coach and had got wet and excoriated, and she attributed the disease to this accident. But then one knew nothing of her habits or place of abode, and it may be inferred that she told as much of her history as she found convenient. Cases are not uncommon in which gangrene attacks one sore, leaving others on the same subject in their usual state; and this fact has been urged as an argument in favor of the disease being primarily local. But in the course of a short time the same change will be observed, if the conditions remain unaltered, to spread from part to part, and that too in spite of the most rigorous attention to cleanliness.

The treatment of hospital gangrene consists, first, in the entire destruction of the sloughing surface by the strongest procurable escharotic. Nitric acid is generally preferred. It should be applied by means of a small mop made of lint wound round a piece of wood of sufficient strength to admit of being pressed into every part of the wound. The eschar thus formed should be allowed to dry and form a hard and charred layer, under which granulation advances with great rapidity. No poultice nor wet lint is needed; and there is no need of hurry in separating the eschar from the parts beneath. Chloroform [or ether] should be administered, as the proceeding is very painful; then a full dose of opium should be given, and repeated if necessary. A liberal allowance of wine, spirits, and other stimulants must be ordered, for patients take large quantities during this state of depression with impunity. Bark and quinine in these cases are frequently useful, and I have given the latter in large doses with success in cases where the application of the acid has failed. Should the sloughing process go on under the eschar, and the repetition of the caustic be impossible or injudicious, the Peruvian balsam may be laid on freely, while the greatest attention is paid to keeping every part of the surface as dry as possible.

But local treatment will frequently prove unavailing, so long as the patient remains exposed to the same influences. He should be removed from the ward or sick-room, and put into another building; and when such a measure is impossible, the ventilation should be as free as possible, while disinfectants should be liberally spread about. No sponges should be allowed; or, after having been used, they should be immediately burnt. Dressings and applications of all kinds should be similarly destroyed when of no further use. And, finally, the surgeon should feel that it were better for the sick to be unsheltered in the open plain than to continue in the crowded wards of an hospital so affected.

[Of the nature of hospital gangrene little more is now known than was twenty years ago, notwithstanding the many investigations made during the American and Franco-German wars. Possibly there may be a definite specific organism developing or propagating the disease. It has not yet been found, only the ordinary bacteria of putrefaction having been observed. Perhaps a peculiar chemical septic material may at times be produced in a wound under the influence of undetermined miasmatic causes, which once formed is readily communicable, and will develop the disease in any wound that may from internal or external conditions be in fit state to take on this form of gangrenous action. Such special *sepsin* has not been presented by the chemists. The disease is usually seen in hospitals in which large numbers of wounded are under treatment. But simple overcrowding does not produce it, and it has been observed sporadically in private practice. Though more likely to be developed in the debilitated, the scorbutic, the overmarched and underfed; it time and again has seized upon the healthiest and most robust. The local symptoms generally, but not always, precede and give rise to the constitutional. The ordinary acute infectious diseases are often prevalent at the same time, and some have seen in hospital gangrene but a wound-diphtheria. Our knowledge, or rather want of knowledge of the producing cause of this disease is well set forth in Heine's

[1] Principles of Military Surgery, by John Hennen, M.D.

statement that "it is a specific poison of unknown nature exerting its action upon the surface of the wound and producing a coagulation of the fluids, which passes step by step through the superficial to the deeper parts."

As respects treatment, it consists largely of *prevention*, by the observance as strictly as possible of the ordinary hygienic rules respecting the lodging, feeding, clothing, and warming of the wounded in hospital; and very possibly also by thorough, careful, "antiseptic dressing." (Nussbaum, for example, reports that whereas eighty per cent. of the wounds under his care just before the adoption of "Listerism" were attacked with hospital gangrene, not a single one was so affected afterwards):—*isolation*, for, however true it may be that the direct communicability of the disease has been denied by some excellent observers, by the great majority its contagious nature is admitted—*free ventilation*, that by dilution and rapid removal, the poison, if it comes from without, may perhaps be rendered inoperative (in this way we may explain in part the recognized advantage of treatment in tents or open huts over that in permanent hospitals); —*thorough cleansing* of the wound, for by the presence of the gangrenous mass, the spread of the disease is promoted. Upon all these points there is an agreement of opinion. But as respects the making of local applications and the most favorable agent to be employed, there is no such unanimity. All the prominent cauterizing agents have been used and with benefit; but it is claimed by some that this benefit is in spite of and not in consequence of the application, and wholly due to the preliminary cleansing of the wounds. The employment of the germ-destroyers has been satisfactory in its results, but the truth of the theory upon which their use is based has not, as we have already seen, been established. Several oxidizing agents have been especial favorites with many surgeons; and substances preventing oxidation, as the various hydro-carbons, have been applied with excellent effect. During the American war bromine (Goldsmith) was most largely employed; nitric acid, permanganate of potassa, and turpentine were used in many cases; and favorable results followed the application of sugar (Packard). During, and just after the Franco-German war in addition to the agents already referred to, camphor (Netter) and glycerine (Demarquay), were largely and satisfactorily used, chiefly by the French.]

Frost-bite.—The effect of cold in producing frost-bite was seen upon a large scale during the war in the Crimea by the surgeons attached to the British and French armies; and there was a peculiar form of the disease affecting the hands and feet, very common during the first winter and spring, which Dr. Tholozan and some of the French surgeons were inclined to look upon as allied to a peculiar disease which appeared epidemically in France between the years 1828 and 1832, and which was then termed acrodynia. Mr. Macleod, however, and with him, I believe, most English surgeons agree, is persuaded that it was the joint product of cold and scurvy. "This affection," he says, "showed itself chiefly in the pulpy parts of the feet and hands, but especially in the ball of the toes, in the edges of the feet, and in the muscular ridge which runs across the sole of the foot at the roots of the toes. Its earliest symptom was a prickly sensation experienced when the patient stood on the foot, and was variously described by him as resembling the pricking of pins, or as if he walked on nails. There were lancinating pains in the calves of the legs, which parts felt hard and brawny, and were sometimes swollen and discolored. There was weariness in the limbs, and a most distressing heat in the feet, especially at night, when the weight of the bed-clothes could not be borne. An erythematous redness was often observed along the edges of the feet or hands; and the sensibility, though generally heightened, was occasionally diminished, so that patients sometimes said, in walking "they did not feel the ground." It was often localized in small patches, and not always accompanied by other scorbutic symptoms. It was often combined, too, with low fever or dysentery, and not unfrequently followed by desquamation of the epidermis, and sometimes by local gangrene."[1]

This affection was intractable so long as the depressing influences on the general health continued; and it was remarked that during the first winter the frost-bites were much more severe and difficult to manage than during the second, when better preparations were made for the occupying forces. The French suffered more than the English. "In their hospitals," says Mr. Macleod, "a limb might be seen sphacelated half-way to the knee."

Any wounds from frost-bite are peculiarly difficult to heal; and "the removal of bone from the fingers or toes, however black and apparently dead, and though only attached by the most slender connection, was certain to cause a great amount of irritation, which sometimes became alarming."[2] The same was noticed wherever the patient was situated, whether in the hospitals, in the camp before the

[1] Surgery of the Crimean War, p. 79.
[2] Op. cit., p. 173.

city, on the heights above Balaclava, or in the warmer regions of Scutari, Renkioi, or Smyrna. Surgeons gave up interfering in any way. The most soothing applications; the greatest gentleness; rest in the horizontal posture; the administration of generous diet and stimulants in proper quantities, were the chief measures found of service. It mattered not whether or no chloroform were administered; a surgical operation to divide even the smallest band was found to be fraught with danger; and special injunctions for non-interference in any way were therefore very properly impressed on the younger surgeons. We have in the Museum of St. Bartholomew's Hospital the feet of a girl aged nineteen, which became frost-bitten during a cold night when she slept in the street. An attempt was made to restore circulation by putting the feet into warm water.

Senile gangrene presents itself under two forms—the dry and the moist. The former (*gangræna sicca*) is due to the gradual decrease in the supply of blood to the part, and is slow in its progress; the latter, also dependent on deficient supply of blood, is more especially influenced by low inflammatory action consequent on irregularity in the circulation, and diminished nerve-power. In the first, the part slowly withers, and becomes dry. In the second, the part, feebly nourished, becomes inflamed, and perishes. This disease, as its name imports, attacks chiefly the old, or those whose constitutions have been injured by excess. Some surgeons have remarked that great eaters, rather than great drinkers, have suffered from moist gangrene; and as early as the days of Cowper, the ossification of the arteries of the legs was noticed in persons who had died of this disease in both forms.[1] A patient may be old from excess, and suffer from gangrene of the extremities at a comparatively early age. A man aged fifty-four was admitted into St. Bartholomew's Hospital, Feb. 22, 1839, with mortification of the third and fourth toes of the right foot; œdema of both legs; cough and expectoration of mucus tinged with blood. The countenance was of bluish aspect, as if there were obstruction in some part to the circulation. The extremities were cold, and the pulse feeble and at times scarcely perceptible. The man died the following day, and the body was removed without examination. An instance of gangrene of the foot at a yet earlier age was under the care of Sir W. Lawrence in St. Bartholomew's Hospital in 1857. The patient, a young man aged 23, had a severe attack of acute rheumatism, accompanied with pericarditis; effusion took place into the cavity of the serous membrane, and the circulation became so impeded that mortification of the foot ensued. Under proper treatment, the mortified parts separated and the stump of the foot healed; but the patient suffered so much from the imperfect nature of the cicatrix, that he again presented himself for admission, being desirous of having the foot removed by amputation, which operation I accordingly performed. Inasmuch as the causes which produce this form of gangrene may come into operation at different ages, the term "senile" gangrene need not be used. The terms "dry" and "moist" express sufficiently the leading characteristics. Mr. James relates a case in which it happened to a woman aged forty-two.[1]

There cannot be a doubt that simple diminution of the heart's action will in some cases be followed by mortification of the lower extremities. We see such occurrences after severe fever; but granular degeneration of the contractile coat of the arteries will, by destroying the equalizing power of these vessels over the circulation, lead to the same result. The action of the heart, however, is not in itself sufficient to preserve the proper supply of blood to all the tissues of the body; the stream is maintained by the contractility of the arteries, and, as recently shown by Mr. Wharton Jones, by that likewise of the veins. In old persons suffering from this form of gangrene the blood has been found thin and insusceptible of coagulation; and in a case where amputation was performed, difficulty was experienced in preventing secondary hemorrhage. Thus in cases of senile gangrene, many conditions may have been combined to lower the vitality, and to render parts prone to mortify from accident, injury, or diseases which under other circumstances would have been trivial in their results. The morbid change has been well described by Mr. Pott:—

"In some few instances it makes its appearance with little or no pain; but in the majority of the cases the patients feel great uneasiness through the whole foot and joint of the ankle, particularly in the night, even before these parts show any mark of distemper, or before there is any other than a small discolored spot on the end of one of the little toes. It generally makes its appearance on the inside, or at the extremity of one of the smaller toes, by a small black or bluish spot; from this spot the cuticle is always found to be detached, and the skin under it to be of a dark-red color. If the patient has lately cut his nails or corn, it is most frequently, though very unjustly, ascribed to such operation. In some patients it is slow and long in passing from toe to toe, and from thence to the

[1] Phil. Trans., vol. xxiii., p. 1195.

[1] On Inflammation, pp. 545–552.

foot and ankle; in others its progress is rapid and horribly painful; it generally begins on the inside of each small toe, before it is visible either on its under or upper part; and when it makes its attack on the foot, the upper part of it first shows its distempered state by tumefaction, change of color, and sometimes by vesication; but wherever it is, one of the first marks of it is a separation or detachment of the cuticle. Each sex is liable to it; but for one female in whom I have met with it, I think I may say that I have seen it in at least twenty males. I think also that I have much more often found it in the rich and voluptuous than in the laboring poor—more often in great eaters than free drinkers. It frequently happens to persons advanced in life, but it is by no means peculiar to old age. It is not in general preceded or accompanied by apparent distemperature either of the part or of the habit. I do not know any particular kind of constitution which is more liable to it than another; but as far as my observation goes, I think that I have most frequently observed it to attack those who have been subject to flying uncertain pains in their feet, which they have called gouty, and but seldom in those who have been accustomed to have the gout regularly and fairly."

Mr. Pott's belief that the idea of the disease proceeding from an ossified state of the arteries is a mere conjecture, has been sufficiently answered by the observations of Thomson and Hodgson.

The treatment of senile gangrene must be conducted upon the usual hygienic principles. If we attempt to combat the disease by "throwing in bark," and by overloading the system with all sorts of stimulants and excess of food, we shall produce an increase of the local vascular excitement, which will be immediately followed by spread of the gangrene. I have known patients over-persuaded to take nourishment against their appetite, but never has the transgression been done with impunity. In cases of humid gangrene, a light farinaceous diet is usually the most fit, and stimulants should be given with caution—port-wine mixed with water being that usually preferred. Opium must be given in doses sufficient to alleviate pain, and should be continued during the day as well as the night. The patient must be confined strictly to bed, the limb kept warm and slightly raised. Finally, let the surgeon beware of interfering with the separation of the slough; nature will accomplish the task best when unaided. Indeed, surgical interference of any kind is, as a rule, dangerous.

In cases of dry gangrene unattended by fever, especially in the aged, stimulants and tonics may be administered more freely, and animal food may occasionally be allowed. But even here excess is to be avoided; the pulse must be consulted and the local disease watched. By care and prudence the life of a patient may be prolonged; and though in general the disease ultimately gets the mastery, many years may be passed in comparative comfort.

Phagedæna, derived from the word φάγω, to eat, is a term applied to a form of ulceration characterized by the gnawn look of the edges, and by the rapidity with which it, as it were, eats away the flesh. If we closely examine a phagedænic ulcer, we notice that the edges are undermined, and that they have the appearance as if they had been nibbled away by the incisors of some small rodent animal. As was observed by Sir W. Lawrence, phagedæna may seem a superfluous addition to ulceration, which always implies loss of substance. It is, however, a convenient practical term to denote cases, not of infrequent occurrence, in which the destructive process is more rapid, considerable, and unequivocal than in simple ulceration.

The various forms of phagedæna constitute an insensible transition from ulceration to mortification—being closely allied to the former in their milder shape, and hardly distinguishable from the latter in their more violent form. Thus we speak of chronic and acute phagedænic ulceration, which in their more active forms become sloughing phagedæna and hospital gangrene.

The present remarks are confined to phagedænic ulceration, or phagedæna. The appearances are as follows. The edge is sharp, often ragged, with livid fragments apparently crumbling away; the margins are often red. The bottom is irregular, grayish, livid or tawny, sometimes with viscid and bloody discharge. In the acuter forms there is a sharp stinging pain, often considerable; in the chronic form it is less marked, or indeed may be entirely absent.

The frequency of phagedæna in the venereal wards of an hospital has long been generally noticed. Into this subject we do not propose to enter, except by saying that it is engendered, from causes quite distinct from syphilis, in young, naturally healthy, yet often delicate females, who lead a miserable life of prostitution in the worst parts of London, with little protection from the coarseness and ill-usage of the lowest characters. Upon such constitutions exposure to cold and wet, the constant use of spirits, want of proper food, fatigue, and broken rest, exert the worst of influences; and any excoriation, aggravated by the effects of uncleanliness, is often followed by the most serious results. But phagedæna is met with in other regions than the organs of generation, and from other causes than those

associated with either habits of prostitution or the depressing associations of syphilis.

It is a fact that the severer forms of phagedæna are less common now at St. Bartholomew's Hospital than formerly, and those which are admitted come from the East End of London, where sailors of all nations and prostitutes make one motley throng. Field-lane and its tributaries are places of the past: air, light, and drainage have greatly changed the diseases of a class, whose habits, however, remain in most respects much the same. Hence we may infer that phagedæna may be induced by endemic causes affecting the general health.

But may not this disease be generated by yet other causes? If it be true that foul air, want of proper food, and other similar agencies suffice to create the spreading sore, how comes it that removal to the pure atmosphere of a well-founded hospital, with all its attendant comforts and the advantages of trained nursing and medical skill, does not at once arrest the morbid action?

To explain this we must suppose the presence of some septic material in the system, which has poisoned the blood, or in other words induced a state of septicæmia. Professor Panum (Arch f. Path. Anat. xxv. 441) has arrived at the following results in respect to the nature of the putrid matters, after a series of experiments:—

1. The putrid poison is not volatile, but fixed; it does not pass over in distillation, but remains in the retort.

2. The putrid poison is not decomposed by boiling and evaporation—not even when the boiling is continued for eleven hours, and the putrid matters are perfectly dried by means of a water-bath.

3. The putrid poison is insoluble in pure alcohol; it is, however, soluble in water, and is contained in the watery extract of the dried putrid substances after their previous treatment with alcohol.

4. The albuminous substances often contained in putrid fluids are not *per se* poisonous, but only become so because they condense the poison on their surface; they can be freed from it by careful washing.

5. The intensity of the putrid poison can only be compared with that of serpents, curara, and the vegetable alkaloids; for after boiling, evaporation, and treatment with pure alcohol, 0.012 gramme of it almost suffices to kill a little dog.

A great number of chemical processes are included in the popular idea of putrefaction; many different products of decomposition are absorbed, and may be injurious; and the circumstances under which decomposing bodies act on the organism vary extremely. It makes a material difference whether a putrid matter passes from the stomach or intestinal canal, and thus acts on the portal vein and liver, or whether infiltrated in the cellular tissue, it excites local irritation; whether it possibly induces inflammation or coagulation in the veins and lymphatics, or whether, after the manner of other poisonous materials, it mixes with the blood, and so exerts both general and local injurious actions.

Such cases as belong to Surgery are distributed under four heads:—

1. Traumatic sepsis (primary traumatic sepsis).

2. Poisoning by putrid matter (secondary infection, self-infection).

3. Infection by the poison of dead human beings and similar matters (infected wounds).

4. The specific zymotic septic process, hospital gangrene, malignant pustule, noma, etc.

It is to the fourth division that the subject of this article is to be referred, whether the disease be called phagedæna, noma, malignant pustule, or any of the other terms generally in use.

Is phagedæna contagious? To this I should reply in the negative, although hospital gangrene undoubtedly is so. But between these two we meet with a class of cases which indicates the necessity of answering with caution.

In 1868 a lad of about eighteen was under my care in St. Bartholomew's Hospital, with a circular foul phagedænic ulcer on the inner side of each ankle, covered by a perfectly black slough. That on the right leg measured full two inches in diameter, that on the left leg was somewhat less. The history was as follows: About a week previously a sheep which he was dragging from a pen got one hoof between his leg and the boot; the skin was a little bruised, but not abraded. In the course of twenty-four hours a pimple formed on some reddened skin: this became a pustule, which rapidly passed into a spreading phagedænic ulcer with sloughing surface. While lying in bed, he brought by accident the two legs together, and on the fourth day after the formation of the first sore, one precisely similar made its appearance in a corresponding situation on the left leg. While in his lodgings the ulceration spread in spite of the usual applications, with great rapidity; but on his removal to the better air of the hospital, under similar treatment, the black scab separated, the phagedænic action ceased, and the ulcers acquired a normal granulating aspect.

Roser affirms that he has seen cases which seem to show the possibility of a septic metastasis to the sacral region. He supposes that in septic poisoning of the blood, a local affection or metastasis is

most liable to occur in such parts as are most dependent—which, in the mass of cases, is the sacral region. He is not disinclined to consider many cases of gangrenous bed-sore as metastatic affections.

The treatment of phagedæna resolves itself under two heads—the general and the local; and while in some cases the former seems sufficient at once to arrest the spread of the ulceration; in others some marked local application, such as the destruction of the surface by strong nitric acid, seems needed, that the processes of repair may be re-established.

General treatment.—All surgeons are, I think, agreed that in the general treatment the main features are, that the strength should be kept up in every way and the nervous irritability allayed. Mr. Prescott Hewett is an advocate for rum and milk in the early morning—a remedy equally pleasant and useful. I usually order the concentrated essence of beef (*i. e.*, four pounds of the meat yielding a pint of soup without water): one or two ounces of this, or more, according to the patient's taste, to be given frequently. Good brandy with hot water, often with an egg and spice, may be given. The rule is the same: stimulants should be administered until the patient is raised from the state of general depression which accompanies this disorder, and frequently very large quantities are required.

Opiates are of the greatest use; they may be freely administered, both for the purpose of checking the local pain and of giving rest at night-time. Medicines do not seem in other respects to exert any marked effects in the acute stages, but quinine or liq. cinchonæ, combined with ammonia, may be administered with advantage. Above all things, the patient should be at once removed to some place where the surgeon knows that the air is pure and uncontaminated; any change is better than to allow him to remain under the same circumstances as those which generated the disease. I am no advocate for keeping the windows open day and night: the chill of the night wind may induce other complications. The state of the atmosphere may be better regulated by limiting the number of attendants, or in hospitals by exercising a proper supervision over the number of patients in the same ward, and the character of the diseases therein aggregated.

So long as the appetite remains impaired, it is of little good to order solid food; but meat may be freely allowed when grateful to the patient, or a mixed diet, such as would be adapted to a person in usual health. It is also desirable to avoid any accumulation in the bowels, although, as a rule, purgative medicine should be administered with care.

The local treatment of phagedæna is governed by clear and simple rules. The sharp stinging pain should be allayed by a lotion containing opium in sufficient quantity. A piece of lint thus saturated may be put on the part, and then covered with a bread-and-water poultice. In some cases a charcoal poultice cleanses the sore. Among recent applications carbolic acid in solution holds a prominent place. It corrects the fetor, promotes granulation, and is supposed to destroy the germs of the disease. Condy's fluid is another favorite application. [Chloral, iodoform, or boracic acid may be advantageously employed, as also nascent oxygen (Day).] In the more chronic cases, benefit may be derived from the use of black or yellow washes; solutions of nitrate of silver; nitric acid and opium; solutions of alum; ointments of various kinds, as the ung. hyd. nit. oxid., the ung. hyd. nitratis, or the ung. rubrum, which contains the bisulphuret of mercury and creasote. Pure creasote may also be applied. In other cases, the simplest applications are the best. In the more acute forms, the surface of the sore may need disintegration by the action of strong nitric acid [or, better, bromine; or, still better, the hot-iron, the galvano-cautery, or the thermo-cautery; indeed, it may be laid down as a general rule that the use of the actual cautery, as soon as phagedænic action is observed, will very much shorten the duration of the trouble, and materially lessen the loss of substance]. This, however, should not be applied unless the rapidity of the destructive process be excessive, or parts of importance, such as a large artery, lie in immediate proximity. The surgeon should ever remember the importance of the preservation of the integument, inasmuch as after the subsequent cicatrization, the neighboring parts may suffer an unpleasant degree of traction.

ULCERS.

By Sir James Paget, F.R.S.

Revised by P. S. Conner, M.D.

The chief interest of this subject, from the surgeon's point of view, is in the study of those forms of ulcer which appear in the integuments; and to these, their diagnosis and treatment, the present essay will be almost entirely devoted. But, first, the general process of ulceration, though referred to in the appendix to the essay on Inflammation, may be briefly considered.

Ulceration is that part or effect of an inflammatory process in which the materials of inflamed tissues, liquefied or degenerate, are cast off, in solution or very minute particles, from free surfaces, or, more rarely, are absorbed from the substance of the body. Not every such process of casting off, however, is called ulceration; when the detached particles are only epithelial, though the process may be essentially the same, it is called desquamation, abrasion, or excoriation; and the name of ulcer is not commonly applied to any result of inflammatory casting off, unless the substance of a tissue deeper than the epithelial be exposed.

Ulceration has very near affinity to gangrene; the two processes, indeed, differ rather in degree than in kind. When the degenerate or dead substance is cast off in one or more portions visible to the naked eye, the process is usually called gangrene, or by some synonym of gangrene; when the portions are not so visible, or are quite dissolved, it is called ulceration. Moreover, the separation of a gangrenous or dead part is commonly effected by ulceration of the living, but inflamed and degenerate, part that bounds it; and this separation is, indeed, the best example, and the most frequent beginning, of the formation of an ulcer. If the process be watched that follows the simple killing of a portion of the body (suppose, a piece of skin suddenly crushed or burnt to death), inflammation is seen in all its environs. After some time, the dead part being decomposed and changed according to the merely chemical characters of its materials, the border of the living part next to it is seen in gradual process of removal. Often this border first loses its inflammatory redness, and looks like a pale-yellowish or white zone, or "line of demarcation," round the dead piece or "slough;" but whether this change occur or not, the border of the living part nearest to the dead is first grooved, and then more and more deeply excavated, till the dead piece is wholly separated and detached from the living.

The surface from which the dead piece is thus detached is an ulcer; and the explanation of the process is, that the layer of living tissue next to the dead piece, being acutely inflamed, degenerates rapidly, is either liquefied or disintegrated, and is thus gradually separated, either in solution or in molecules suspended in the liquid inflammatory product.

An essentially similar removal of inflamed structures by ulceration, that is, by solution or molecular disintegration and ejection, may be seen in any spreading ulcer of skin or mucous membrane, of bone or cartilage. Here, there may be no death of visible particles, no sloughs, but the inflamed and rapidly degenerating structures are cast out as by what some have called a molecular gangrene.

It would be needless repetition to describe the minute changes which the degenerating inflamed structures undergo before being cast off: so far as they are known, they are described in the appendix to Inflammation. With them there is always discharged some liquid, in which they are suspended or dissolved. The appearance and properties of this "discharge," or "ichor," are various, according to the causes and characters of the ulcerative process. When the process is very active, the ichor is usually a thin, yellowish or grayish fluid, often tinged with blood, albuminous, not spontaneously coagulable, containing abundant molecular matter, the débris of the ulcerating structures, and corpuscles like ill-formed pus-cells. From some ulcers, *e. g.*, the primary syphilitic, it is contagious; from many it appears corrosive, not indeed as having a directly solvent power, but as exciting by its acridity, or by the "catalytic" influence of its own decomposition, inflammatory and degenerative changes in the tissues with which it is in

contact. From many ulcers, again, the ichor or discharge is peculiarly "foul," *i. e.*, it rapidly decomposes, yielding putrid or rather offensive gases, or it contains putrid fragments of the ulcerating structures, or of granulations which die prematurely. Such is, commonly, the character of the discharge from the most rapidly destructive ulcers; while, on the other hand, the more an ulcer tends towards healing, the more does its discharge become like "laudable" pus.

So long as an ulcer is in progress, the tissues next to it are inflamed, and usually are in that state of inflammation which is understood as "low," being marked (at least, in the integuments) by a dusky redness, heat which feels to the patient burning and pungent, and with very little production of organizable matter. Commonly, the ulcerating surface is abrupt, looking jagged, or eroded, dusky, brownish or yellowish, mottled, without granulations, ready to bleed. The more active the progress of an ulcer, the more marked are these characters in the structures around it; and when its progress ceases and healing begins, these characters are exchanged for those of the healthy "determination of blood," which, without inflammation, attends the production and development of reparative granulations.

The healing of an ulcer differs in no material point from that of an open wound with loss of substance. It is a healing by granulations; and though the shape and other characters of the cicatrix often have peculiarities indicative of the disease that it has repaired, there is no known difference in the process of repair (see WOUNDS).

What has now been said of the general process of ulceration is applicable for an explanation of the process by which all or any of the numerous forms of ulcers are produced; we have no knowledge by which to explain the peculiar and characteristic forms that they severally present. Nevertheless, the diagnosis and import of these forms are of high interest in surgery.

The chief forms of ulcers may be best named and arranged, in the first instance, according to the constitutional or specific diseases which they severally indicate or are derived from. For each constitutional disease in which ulcers are apt to occur, may be said to express itself in them by the peculiarities of shape, size, and other qualities by which they are severally distinguished from a common ulcer, such as may exist in a healthy person after the separation of a slough from accidental violence.

Another nomenclature and arrangement of ulcers, which has been very generally adopted, is derived from characters which they present in certain local or accidental conditions. Thus ulcers are named irritable, chronic, sloughing, etc. But many of the characters implied by this nomenclature are transitory; many are accidental; some may belong equally to two or more kinds of ulcers that are essentially different and require different modes of treatment.

The plan then, that will be here followed is that of describing, first, each of the chief varieties of ulcer, distinguished according to its constitutional or specific origin. The type with which to compare and contrast each of them is the simple ulcer, left at the separation of a slough, after injury, in a healthy person; and the type of each distinct form or variety must be in the characters which it presents in its most frequent appearance, or in which it is prone to continue when not disturbed, for either good or harm, by any external circumstance. In a second section will be a description of the subordinate or accidental varieties of appearance which may be found in, or connected with, any of the chief forms of ulcer (though not with equal frequency in all), according to external circumstances.

A common, simple, or healthy ulcer, as already said, is such an one as is left after the separation of an accidental slough in a healthy person. In many of the points wherein other ulcers show some of their chief diagnostic marks, the characters of the simple ulcer are, of course, negative or accidental. Its locality, shape, size, and number, depend on the injury which it has followed. If only the skin has been destroyed, its base is level, slightly depressed (the less so, the more nearly its healing is completed), uniformly covered with small florid granulations, which feel soft, pliant, and elastic, and, though highly vascular, do not readily bleed and are not painfully sensitive. The edges of the common ulcer shelve gently down to its base, and feel scarcely harder than the adjacent healthy skin. At their junction with that skin they are generally opaque-white, with a very slight thickening of epidermis; within this they have a pale purplish-blue tint, where the new-formed epidermis veils the color of the healing granulations; and yet within this the granulations have a deeper hue than those nearer to the centre of the ulcer, being most vascular where the cuticle is being actively developed. The pus from such an ulcer is "healthy" or "laudable" (see ABSCESS); the parts immediately beneath and around it are somewhat more vascular than is natural, but are not otherwise changed. Such are the characters, by their deviations from which all other

ulcers are distinguished, and by their approaches to which they indicate their tendencies to healing. For the healing of a simple ulcer may be called spontaneous, as that of a granulating wound may be; and for both alike no other treatment is necessary than exclusion from injury.

Inflammatory ulcers — that is, ulcers having their origin in an inflammation of low type, but not specific, or else in some constant irritation — are among those least different from the common type. They usually have their origin in some slight injury, a scratch or blow, such as a "broken shin," which a healthy person might have suffered with impunity. Their most common seat is on the lower half of the leg, and they are commonly single; they are usually less than an inch in any diameter, and of irregular shape; their bases are generally level, very little depressed, ragged, or flocculent, without granulations, ruddy, looking raw, or else ash-gray, or yellowish with adherent thin slough; their edges are abrupt, irregular, or shreddy; their pus, or ichor, is thin, watery, excoriating, not unfrequently blood-tinged. The skin round an inflammatory ulcer is usually full-red, bright or dusky, according to the patient's general condition, hot and burning, and the whole seat and neighborhood of the disease feel very painful, burning and aching, "down to the bone;" not rarely, also, the surrounding tissues are œdematous or in patches excoriated.

An inflammatory ulcer, unless it be due to some constant external irritation, always indicates general unhealthiness in the patient, but not always the same defect or error of the health. It may be found in the well-fed and plethoric of all classes, but is probably most frequent in the infirm and old, the ill-fed and overworked. There is, therefore, no specific or single method for its general treatment. This must be decided by the condition of each patient, just as that of any other active inflammatory disease must be. For local treatment the chief means are leeches, applied at a distance from the ulcer, *e. g.*, near the knee or on the foot, if the ulcer be at or near the middle of the leg; warm water dressing, or lead-lotion applied warm, or poultices; complete rest of the part, and (if it be the lower limb) recumbency with elevation of the limb. Bandages, ointments, and plasters are usually to be avoided till the ulcer shows signs of healing. With less favorable changes, the inflammatory ulcer is especially likely to be excessively painful (see *neuralgic ulcer*, p. 447), or to become chronic; much more rarely it assumes strumous, or syphilitic, or other specific characters derived from some constitutional disorder in the patient.

Eczematous ulcers merit distinction from the preceding, although like them in many characters, especially in their most frequent seat, their usual shape and size, and characters of base and margin. They may have their origin in slight injury, the ulcers forming as in the last kind, and the surrounding inflammation assuming an eczematous instead of a common character, the skin becoming punctate or vesicular, or, in old persons, purpurous, or cracking and exuding an adhesive ichor with constant itching. But they are often spontaneous, the ulceration taking place in the middle of a patch of acute eczema.

In either case the general treatment must be guided by the character of the disease of the skin. The remedies for eczema must be used, regard being had especially to the gouty, strumous, or other constitutional disposition with which it is in each case connected. For local treatment it may be noted that such ulcers seldom tolerate ointments or dry bandages. In general, the best applications are water-dressing or wet linen-strapping; if the skin around the ulcer exude profusely, it may be covered with daily-renewed pieces of blotting-paper, or dusted with starch, or, best of all, be occasionally washed with a strong solution of nitrate of silver, which is equally a good remedy for the ulcer itself.

It is probably these, more than any other ulcers, that have given rise to the question whether ulcers should always be cured if possible. There is sufficient reason to believe that the cessation or cure of an established eczema has been attended with serious disease of the brain or other internal organ; the same may happen with an ulcer of this, or probably some other kinds. The event is certainly very rare, but it may often be right to guard against it by making an issue in some place more convenient than the ulcer, or by renewing the cutaneous disease with counter-irritants, especially by frictions with croton-oil liniment.

Although eczematous ulcers alone are here named, yet it may be noted that ulcers may occur in several other forms of cutaneous eruption. They are, indeed, frequent in all the severer forms of the acute eruptions in patients that are cachectic: whether with intense struma, or syphilis, or through defective food, foul air, or other depressing influences. But at present it is sufficient only to mention these ulcers; their diagnosis and treatment are to be determined by the eruptions with which they severally occur, and with the accounts of which they will be described hereafter.

Cold ulcers should be distinguished because of the peculiarity of constitution on which they depend, and which often has to be considered in the treatment of other ulcers of various kinds. They are like small inflammatory ulcers, occurring spontaneously in the extremities, especially at the ends of the fingers or toes, or at the roots of the nails. In some cases they are preceded by severe pain and small gangrenous spots. They are in many respects like ulcerated chilblains, but they occur without any exposure to intense cold, in patients whose feet and hands are commonly, or even habitually, but little warmer than the atmosphere they live in. Such patients are among those who say they are never warm; and the skin of their extremities, unless artificially heated, is to the touch like the surface of a cold-blooded animal. The blood must flow in these parts so slowly, that there is time for it to be cooled nearly to the temperature of the atmosphere; probably it is often stagnant, or scarcely circulating.[1] With this defect, which in its smaller degrees is very common, especially among women, the usual coincidents are a small feeble pulse, a dull or half-livid tint in the parts which in healthy people are ruddy, a weak digestion, constipated bowels, and scanty menstruation. The cure of the ulcers, and prevention of their recurrence, lie in the remedy of these defects. Many tonic medicines may be useful, but the most so is iron, in whatever doses the patient can take it. With it purgatives are generally necessary; *e. g.*, small doses of mercury and aloes, or of sulphate of magnesia. Full diet, also, is usually required; exercise in the fresh air; very warm clothing, especially of the lower half of the body; and warm bathing. Dry applications, or lotions with sulphate of zinc or of copper, are the best local means, and the part must be kept warm; healing is always tardy or quite arrested at a temperature far below the natural heat of the body.

Senile ulcers present, usually, many of the characters of inflammatory ulcers of the lower type, but should be distinguished because of the peculiarity of their origin and coincidents. They have no distinctive characters of shape or size, but are especially dry, secreting little even of ichor; and they have a kind of rusty-ruddy tint of their granulations, and are surrounded with a dusky-pink or red area. And these characters correspond with those of the tissues in which the senile ulcers are found, for they are most common in the dry withered limbs of those who are shrinking, as they grow old with either a timely or a premature degeneracy, and whose arteries are probably advanced in degeneracy. The surrounding skin is usually dry, thin, brownish, scaly; it may be eczematous; and its veins, especially those near or below the ulcer, are large or stellate. Often, also, some part of the border of the ulcer sloughs; the slough, with a well-defined boundary, yellowish or grayish-white, extending into the adjacent skin. Thus, in some cases, the ulcer spreads at one part while it may be healing at another; extending with a kind of senile gangrene of the integument, similar to that in which it may have had its origin. Such spreading is usually preceded or accompanied by aggravation of the pain with which the ulcer is associated, but which, except at such times, is seldom considerable.

The general treatment appropriate for senile ulcers consists chiefly in giving such good food and wine as, under nearly all conditions, those who are withering require. Bark, also, is commonly useful, and the mineral acids; and in cases attended with sloughing, opium often appears to be a very valuable remedy. For local treatment, stimulant ointments, or balsams, or these in combination, commonly do more good than stimulant lotions, which rather wither the granulations that may be forming; or than water-dressings, which are apt to produce irritable eruptions about the sores. A very useful plan, when the disease is extensive, is to strap the limb daily with a mixture of resin-ointment and Peruvian balsam spread on strips of lint or linen.

Strumous ulcers, most of which, it is probable, might be also called tuberculous, are most commonly seen as the consequences of strumous or scrofulous suppuration in the subcutaneous tissue or lymph-glands; but they may appear without any such preceding disease. In this case, the usual stage previous to ulceration is that of slightly elevated, pale red or pink, circumscribed thickenings of the skin, like cutaneous tubercles. These may appear singly or in groups; and may, perhaps according to their duration, be firm, or softish, or boggy, as with a softening of their substance. This last state, which is probably a kind of imperfect suppuration or softening of tuberculous matter under the skin, immediately precedes the ulceration. The ulcers, whether formed thus or after the wide opening of strumous abscesses in the lymph-glands or subcutaneous tissue, are most frequent in the neck, groins, cheeks, scalp, and the neighborhood of the knee, ankle, wrist,

[1] Experiments are wanting to prove how deeply this coldness extends. The writer put a thermometer in a wound made in the division of a tendo Achillis in a cold-footed young woman, and it showed only 70° F., the atmosphere of the room being 65°.

and elbow. They are often multiple and clustered. They generally affect an oval shape, but by coalescence may be irregular and variously sinuous and of great extent, though singly they rarely attain an inch in diameter, and have little tendency to spread. The margins of strumous ulcers are commonly formed of undermined, overhanging skin, which may be either thin or irregularly thickened, without induration, and either pale pink or purplish, according as the circulation is more or less

[Fig. 66.

Strumous ulcer of leg. (Erichsen.)]

free in them. The bases of the ulcers are usually unequal, soft, covered with large, soft, œdematous granulations, which are often pale, and bleed on slight contact, and sometimes project exuberantly above the surrounding level. The pus of strumous ulcers is commonly thin, greenish-yellow, seldom irritant; they are rarely very sensitive or painful. The parts around them may be healthy; but when the ulcers have existed long, and especially when they are connected with old strumous disease of bones or joints, all the adjacent textures are generally greatly enlarged with œdematous infiltration, and clogged together.

By these characters strumous ulcers may, almost always, be recognized; but the diagnosis is assisted by the coincidence of the known signs of the strumous constitution, or of similar disease in other parts or tissues. And these coincidences indicate the general treatment, of which the chief constituents must usually be either preparations of iron, especially the iodide or phosphate, cod-liver oil, quinine, or iodide of potassium; occasional purgatives, or small doses of mercury; fresh air, especially by the sea, or on high hills; free exercise; bathing; and scrupulous attention to the digestive organs, which are very commonly disposed to receive more and other food than they can make good use of. The local treatment of the ulcers (excluding the cases in which they are connected with diseases of the bones or other deep-seated parts) must generally be stimulant. For different cases, which it may be impossible to define, the ointments with iodine, or the iodides of potassium, lead, or mercury, may, any or all of them in succession, be found valuable. Or lotions of the iodides may be used, or of the astringent metallic salts, or of nitrate of silver. An excellent way of applying these, when the ulcers are on the limbs, is with strips of linen or lint soaked in the lotion, and put on as firm strapping. Of numerous popular applications, the best, probably, is a poultice of bruised and warmed sea-weed. When the skin is very much undermined and burrowed, its destruction with potash, or some similarly acting caustic, is often very useful.

Cases occur, though rarely, in which amputation is the only remedy for strumous ulcers. They are chiefly when the ulcers are about the ankle-joint, and attended with great œdema of the foot, or when they are deep enough to have involved some bone or joint; but no general rules of treatment can be here laid down.

The scars of strumous ulcers may be causes of ugliness and deformity, either by contraction or, more commonly, by overgrowth, and the formation of bars raised in radiating lines, or networks, or tongues of skin. In such cases, excision of the scars may be necessary; but in many instances a great part of the excess of scar may be removed by repeated slight blistering, and with time nearly the whole will level down.

In superficial scrofulous ulcers on the hands and feet a peculiar appearance is sometimes produced by an excessive growth of the papillæ at the base or borders of the ulcer. In either, or in both situations, they give the ulcers a remarkably warty character—a character which is often maintained when the ulcers are healed—and leave a coarse, nodular, and warty patch of skin, with opaque, thick cuticle. At first sight, such ulcers might be taken for papillary epithelial cancerous disease; but the diagnosis is easy, through their being often multiple, having no hardness of granulations or of base, no sinuous or upraised border, no rapidity of progress.

These warty strumous affections may be cured with repeated painting with tincture of iodine, or with the most stimulant of the iodine ointments.

Scorbutic ulcers.—Popularly, many kinds of ulcers are thus named; especially the inflammatory, eczematous, and some of the strumous. But the name should be reserved exclusively for those that derive their peculiar characters from the exist-

ence of scurvy. Mr. Busk, whose great experience on board the Dreadnought Hospital-ship has given him an unequalled knowledge of scurvy, has kindly supplied the writer with the following note :—

"Although scurvy in itself cannot be said to be attended with any peculiar form of ulceration, ulcers or sores of any kind already existing from other causes assume, in consequence of the scorbutic taint, a more or less peculiar character, and when thus modified have usually been termed 'scorbutic ulcers.'

"Scurvy essentially consists in an alteration in the constitution of the blood, which leads to the effusion into the various tissues of a fibrinous exudation, usually deeply colored, and which has on that account been commonly regarded as a simple coagulum. That this effusion, however, can scarcely be regarded in this light, is proved by several considerations, but more especially by the circumstance that it is, from the first, solid and capable of becoming imperfectly organized—that is to say, it is after a time permeated by newly-formed vascular channels. It is the presence of this effusion which causes the spongy swelling of the gums, the tumefaction and induration of the intermuscular tissue, the so-termed scorbutic nodes, and which, when poured out on the surface or in the substance of the corium, constitutes the vibices and petechiæ so characteristic of the disease. It is the effusion also of the same semiplastic material on the free surface of sores or ulcers which gives them the peculiar aspect termed 'scorbutic.'

"Ulcers of this kind are distinguished by their livid color and irregular tumid border, around which no trace of cicatrization is evident; whilst the surface of the sore is covered with a spongy, dark-colored, strongly adherent, fetid crust, whose removal is attended with free bleeding, and is followed by a rapid reproduction of the same material. This crust, in bad cases, as remarked by Lind, attains to a 'monstrous size,' and constitutes what has been appropriately termed by sailors 'bullock's liver.'"

Gouty ulcers.—Persons of gouty habit are among those most liable to inflammatory and eczematous ulcers; but the form to which this name is specially given is that found in distinctly gouty parts, or over gouty deposits. Such ulcers are usually superficial; and even when they occur on the palm or sole, and extend through thick cuticle, destroy only the surface of the cutis. They are circular, if of any definite shape, with low shelving borders, and with bases that are either florid and without granulations, or covered with a thin yellowish or grayish layer, like a soft slough. They discharge a thin ichor, which commonly, as it dries, leaves a white chalky deposit; and they are exceedingly slow in getting either better or worse. The parts around them are usually healthy, except in so far as they may be gouty.

The general treatment of gouty ulcers must be determined by the general condition of each case. Locally they may be best palliated by the simplest applications, such as water-dressing or simple cerate; or cured by washing with solutions of from five to ten grains of nitrate of silver to an ounce of water.

Syphilitic ulcers.—Those that are primary need no mention here, except to indicate the necessity of being on the watch for the diagnosis of such as occur on the lips, fingers, and other parts on which they are rarely seen, and more rarely suspected by the patients. And secondary diseases of the integuments are very seldom ulcerative, unless when pustular eruptions occur in the cachectic. Tertiary syphilitic ulcers, however, are so frequent, and their diagnosis from all others so important, that although it may involve repetition, they must be described here as well as elsewhere. They usually appear among the latest signs of syphilis, and are most severe in those who are most reduced, whether by the syphilitic poison abiding in them, or by mercury, or both, or by poverty, intemperance, or naturally unsound constitution. There is probably no form of ulcer in which the influence of all these evils is more intensely felt.

Two principal forms of tertiary syphilitic ulcers may be distinguished at, or near, the beginning of their formation; of which the one usually succeeds to rupia or some other ulcerating eruption, and the other follows subcutaneous indurations with circumscribed infiltration of the tissues (*gummata* or *syphilomata*, as they are sometimes called). In their later stages, the two forms may be not distinguishable; but they generally maintain the difference of being, the one superficial, the other deep; the one extending through only the cutis, the other into or through the subcutaneous tissue.

The more superficial tertiary syphilitic ulcers may be known, in many cases, by being commingled with well-marked eruption; but when this is not the case, the signs most to be relied on are as follows: They may occur on any part, but are most frequent on the trunk, as on the back, shoulders, nates, and, in next frequency, on the limbs. Their most frequent shapes are circular, annular, or crescentic, or horseshoe-like. The annular shape, in which a round or oval portion of healthy or scar-like skin is surrounded by a ring of ulceration, which often extends at its outer border while healing at its inner, is

almost certainly characteristic of syphilitic disease; and equally so is the ulcer in the shape of the crescent or horseshoe, which commonly heals at its concave, even while extending at its convex border. Such ulcers may be single or multiple, and in the latter case may be grouped or arranged in a circle, or some other curvilinear figure. They may be of any size, from half an inch to five or six inches in diameter, and generally are smallest when they are most numerous. Their edges are usually abrupt, sharp-cut, or sometimes jagged; not undermined, or elevated; bounded by skin which appears little changed in texture, but may be ruddy, or highly vascular. Their bases are usually level, little depressed, uniform, dusky or dark crimson, or more florid, with soft small granulations, if any. Their discharge very commonly concretes into scabs, which may partially or completely cover them, and may be heaped up like those of typical rupia.

Tertiary syphilitic ulcers of this kind are not usually associated with evident disease in the textures adjacent to them. They have themselves no induration, and, rarely penetrating beyond the *cutis vera*, they leave the subjacent tissues, as well as those round them, soft, pliant, and apt for rapid healing, with smooth and glistening scars that scarcely contract or adhere to parts under them.

Generally, the ulcers of this kind are not associated with any other active form of syphilitic disease, though their diagnosis may often be assisted by the marks of such disease past-by. Neither have they any attendant constitutional disorder other than belongs to the several degrees of syphilitic cachexia; and they are seldom very painful, unless when seated on the hands or feet.

The deep tertiary syphilitic ulcers usually have their origin in circumscribed indurations, of a doughy, inelastic consistence, in the subcutaneous and sometimes in yet deeper tissues. Such indurations are at first painless, and scarcely involve the cutis; it passes smooth over them, level, or but slightly upraised. But after the lapse of an uncertain time (it may be less than a week, or more than a month), the central part of the induration becomes soft, and feels boggy or rotten; the cutis becomes adherent, red and thin, and all the diseased part more painful. Then the thin skin ulcerates, and at once the diagnostic characters of this form of ulcer are established.

Such ulcers are most frequent on the extremities, especially near the knee or the elbow or the shoulder; but they may be found anywhere, and are not rare on the lips, forehead, alæ of the nose, and other parts of the face, on the palate and the tongue. They are usually circular or oval, seldom less than a quarter of an inch or more than an inch in diameter. There are more often many than one at the same part, and not rarely several are found in different stages, or of different dates of formation. The edges of these ulcers are usually very sharp-cut, abrupt, sometimes going right down through the thick substance of the induration, as if a piece had been punched out of it. The edges are rarely either undermined, elevated, or everted; and as they extend, the whole substance of the induration is pretty uniformly destroyed. Their bases are not unfrequently covered with slough, due apparently to the degeneration and death of the indurated substance in which the ulcer had its origin. Or, when not sloughing, the bases of the ulcers are commonly deeply excavated, without evident granulations, resting on the deeper subcutaneous tissue.

Ulcers of this kind are seldom painful unless when accidentally inflamed, and are remarkably little affected by posture or those other external conditions which notably modify the characters of ulcers that are less evidently specific. The tissues adjacent to the induration which surrounds these ulcers are in the first instance little affected; but as the disease extends, or has been from the first deep-seated, they may become even very deeply involved, *e. g.*, to the deep fasciæ, or muscles, or periosteum. Very commonly, too, an area of dusky redness surrounds the ulcer, and the duskiness may be noted as one of the signs by which these tertiary syphilitic ulcers may be distinguished from certain strumous ulcers which are much like them, but have surrounding areas of a bright pale pink.

A well-marked, though not intense, cachexia is often (but far from always) associated with these ulcers, and periosteal or osteal pains may coexist. Yet more generally they are the only present signs of syphilis; the disease seems to localize itself in them; and it is not very rare to find patients, who have continued for ten or more years subject to these ulcers, but to no other form of syphilis, and even having these ulcers on only one part, *e. g.*, on one lower extremity.

Little need be said here of the treatment of the tertiary syphilitic ulcers. It must be according to the general rules which will be laid down in the essay on SYPHILIS; yet a few rules may be mentioned. As with all specific ulcers, so with these: specific treatment is of little or no avail, but may be mischievous, while they are the seats of acute inflammation. This, though it be but an accidental complication, must be reduced by ordinary means before specifics can be

profitably given. Iodide of potassium in such doses as three grains twice a day, very rarely fails to cure any ulcers of either the superficial or the deep form; but just as rarely is the cure permanent. Again and again after treatment with this medicine ulcers recur in or near the scars of their predecessors; and the choice lies between repeating such temporary cures, till in time the disease as of itself ceases, or the employment of mercury.

The local applications must generally be stimulant; and among the best materials for dressings are the ointment of the nitric oxide of mercury, and the black wash. If there be no acute inflammatory or other complication, either of these may be used till the ulcers are completely healed. In the event of such complications, the tertiary syphilitic ulcers are among those for which the plan of water-strapping is best adapted.

In connection with the history of these tertiary ulcers, it should be mentioned that ulcers exactly like them may be found in young persons that have inherited syphilis; that there is some reason to believe that they may be imitated by the effects of mercury given for other than syphilitic diseases; and that when tertiary syphilis occurs in persons of strumous constitution, ulcers may appear of intermediate characters, in which it may be impossible to make a diagnosis, unless by the influence of iodide of potassium, which appears to be the greater in the same proportion as syphilis enters more largely into the constitution of the disease. Moreover, there are certain forms of ulceration prevalent in some tropical climates, and occurring among Europeans therein, which very closely resemble these tertiary syphilitic ulcers, and are like them curable with iodide of potassium.

Lupous ulcers will be described with the DISEASES OF THE SKIN, the tubercular condition of the cutis which usually precedes them having given to "lupus" a claim to a place among cutaneous eruptions; but their chief diagnostic characters may be mentioned here. Occurring usually in persons of marked strumous constitution, they are most frequent on the face, especially on the tip or alæ of the nose, and the upper lip or cheek. They are not very rare on the external female organs of generation. Often also they are seated on the boundaries of the skin and mucous membrane of the nose, extending on both; or, with ulcers on these parts, others may be found perforating the septum of the nose or in the pharynx. A circular ulcer perforating the lower and anterior part of the nasal septum, slow in progress, and generally healing when it is rather more than half an inch in diameter, is a very characteristic form of lupus associated with tuberculous inheritance.

Lupous ulcers are commonly preceded by one or more flattened, slightly elevated, firm, oval or roundish, pink tubercles or thickenings of the cutis. These perish in the ulceration, and the extension of the ulcers is not usually preceded by thickening of the cutis next to be invaded. The ulcers take the shape and number, and in the first instance the size, of the tubercles; but they soon extend and coalesce, destroying in their progress not cutis alone, but deeper textures, as the cartilages and bones of the nose, the mucous membranes, or any others that may stand in their course. And this progress is not with sloughing or any signs of active inflammation, but with constant and, it may be, slow ulcerative destruction of the borders of the ulcers.

The borders are generally abrupt, irregular, "eaten," sometimes slightly elevated or thickened and firm, very rarely undermined. The bases may be nearly level, pale, and almost void of granulations, or they may be covered with coarse, dusky, prominent granulations, raised highest at the centres. In either case the ulcers are very often scabbed over, by the drying and concretion of their discharge; but the scabs do not facilitate scarring beneath them; rather, they favor the progress of the ulcers. The ulcers are seldom painful or prone to bleed, even when their granulations are prominent, and the parts around them and beneath their bases are generally healthy. Coincident with them may be any form of strumous disease or of its consequences.

Lupous ulcers are the first to which can be ascribed that property of cancerous or malignant diseases which consists in their proneness to extend irrespective of tissues. But this character is not sufficient to prove that they have relationship to cancer; their most evident affinities are with struma and tuberculosis. These indicate the most useful constitutional treatment, namely, that with cod-liver oil (which may need to be given in very large doses) or other remedies for struma. And it is to be observed that when tertiary syphilitic ulcers occurring on the face imitate many of the characters of lupus, these remedies are wholly useless for them, even more so than is iodide of potassium for the true lupous ulcers of strumous origin. But besides, local treatment is essential. A long course of very active stimulants, such as turpentine, may heal lupous ulceration; but such healing is insecure, and the disease is very apt to return in the scar. It is better to destroy the whole borders and base of the ulcer thoroughly with some escharotic, which may penetrate far

enough to reach healthy structures. What escharotic should be chosen must be determined by the conditions of each case.

Rodent ulcers (also often called lupoid, cancroid, etc.) have several characters in common with those last described; yet their difference is proved, among other distinctions, by their occurring as generally in the later half of life as the lupous do in the earlier; and by their affinity with cancer, and not with struma.

They usually originate in some tubercular or scaly spot of long duration on the face, on which repeated formations and off-castings of dry crusts and scales may have been observed. Their most frequent seats are the cheeks, eyelids, upper lip, nose, and scalp; but ulcers of essentially the same characters may occur on the vulva, vagina, areola of the breast, by the anus, or perhaps many other parts. They are usually single, and not symmetrical; circular or oval in the first instance, but in their progress becoming quite irregular in shape, extent, and depth. Their borders are seldom much elevated or distinctly nodular or lobed; but are usually either abrupt or smoothly rounded, or with low tubercles in or near them, not undermined or everted. But the borders and the base feel tough or hard, as if formed or bounded by a layer of indurated tissue from half a line to a line in thickness. Beyond this layer all the tissues adjacent to a rodent ulcer appear healthy. The surface of the base is generally smooth, and, it may be, level; dull reddish yellow, looking half-dry and glossy, void of granulations, yielding very little discharge of any kind. It very rarely bleeds, or gives acute pain, or has any exuberant up-growth of granulations, or any warty or lobed structure, such as is so common a characteristic of the epithelial cancerous ulcers, to which, in some respects, the rodent bear a close resemblance. In very rare cases, a distinct subcutaneous growth may be found at the border of a rodent ulcer. In such a case the writer found a firm, elastic, rounded mass, nearly an inch in diameter, pale-grayish, yielding no cells or other structures like those of epithelial or any other form of cancer, but small corpuscles like those of ordinary granulations. After the removal of the mass with the rodent ulcer, and the adjacent part of the ear by which it grew, the patient lived twelve years without recurrence of the disease, and then died with senile gangrene.

The progress of a rodent ulcer is usually very slow, but if not checked by treatment, it is very sure, and at any time liable to be accelerated by accidental inflammation. It constantly extends wider and deeper, destroying every tissue that it invades, yet maintaining throughout the same general characters of base and border, and the same usual absence of attendant growth. Such ulcers may destroy great portions of the face, and penetrate so as to expose the pharynx or the nasal cavities, or the brain, or any deepest-seated part. Thus they may be fatal; but to the last, they have no associated similar disease in the lymphatics, or in any distant part, and no other cachexia than may be due to the feebleness which they cause. Indeed, it is often a subject of wonder when the contrast is observed between the horrible ravages of a huge rodent ulcer of the face, and the apparently undiminished general health and strength with which the patient bears it. In no other equally destructive disease is such a contrast seen.

The treatment of rodent ulcers must be complete extermination. The knife, or escharotics, may be used, according as the circumstances of each case may decide for one or the other; but generally escharotics are to be preferred, as being equally efficacious with excision, and attended with less risk. No general rule can be given for choice of escharotics; but usually, for the smallest ulcers, arsenic is most convenient; for the larger and more superficial, the nitric acid, or acid nitrate of mercury; for the larger and deeper, the Vienna paste, or pastes with chloride of zinc. After thorough extirpation of all the boundaries of the ulcer, and of whatever tissue near it may be indurated, there is, generally, no return of disease. If there be, similar treatment must be resumed; and it may be continued as long as there is any probability that the whole disease may be destroyed at once.

Cancerous ulcers vary according to the forms of cancerous growth with which they are severally connected, and with the description of which they will be again referred to. But for their diagnosis from other ulcers, two modes in which they occur should be noticed. In one, the ulceration begins in the skin over, and adherent to, a cancerous mass, into which it extends as it deepens; in the other, the first changes appear to be in the cancer itself, and the ulceration is by opening of the skin from within. The two modes may coincide, and their final results may be the same; but the distinction between them is worth observing.

In the ulceration from the surface inwards, the skin over a cancer becomes gradually thinner, adherent, tinged with blood, dusky-red or brownish; then it cracks, or is excoriated, or scabs; the excoriation widens and deepens, till the surface of the cancer is exposed. If, now, the cancer be prone to rapid increase (as medullary cancers usually are), it will generally protrude through the ulcerated opening in the skin, as a so-called fungous

mass ; if less active, the ulcer generally deepens into it, and then may acquire slowly the characters of those that commence in the cancerous substance.

In this manner of formation, the cancerous ulcer may have no characteristic shape, but may be known from any of the forms already described by the characters of the morbid growth beneath it ; and from ulcers over other than cancerous growths (at least in most cases) by its occurring, not through stretching or mere inflammation of the skin, but through the skin becoming constantly thinner, and then in its residue cancerous, *i. e.*, infiltrated with cancer.

In the other manner of ulceration, degenerative changes usually first ensue in the cancerous mass, with softening, and, it may be, an ill-conditioned suppuration. The materials thus formed are discharged, with sloughing or ulceration, through the surface, leaving in the cancerous mass a cavity like that of a widely-open abscess walled-in with cancer. Then, with continued ulceration of their internal surface, and at their open margin, the cancerous boundaries of the cavity or ulcer still constantly increase by the addition of new cancerous matter ; so that, though the ulcer continually enlarges, it does not destroy the cancer ; rather the growth extends more rapidly than the destruction, involving the adjacent structures more and more widely and deeply.

The essentially distinctive character of these ulcers is the cancerous structure which bounds them, and in which, indeed, rather than in any natural tissue, they are found. To the growth of this structure, also, they owe chiefly their shape and other features. They are usually roundish or oval in their general outline. Their edges are generally raised and everted by the exuberant formation of cancer in and beneath the boundary of the skin ; and the raised margin, which may be also undermined, is usually hard, nodular or warty, and sinuous, imitating the structure of the cancerous mass. The base of a cancerous ulcer is similarly hard, nodular or warty, or covered with coarse granulations, uneven, deepest at its centre, not rarely bleeding without apparent cause. The discharge is usually a thin, acrid, strongly smelling ichor, which, in cases of superficial ulcers, and in old persons, often concretes into a dry and almost horn-like scab.

The structures beneath and around a cancerous ulcer being usually infiltrated with cancer, are hard or firm, through a layer from a line to an inch or more in thickness. The adjacent skin may be warty, with large papillæ. The lymph-glands in relation with the seat of the ulcer may be enlarged and hardened, and may thus give decisive evidence for diagnosis, if they maintain their morbid condition, although there be no accidental irritation or inflammation in the ulcer. For, with such irritation, any ulcer, as well as a cancerous one, may give rise to a corresponding enlargement of lymphatics.

The treatment, and other matters relating to cancerous ulcers, will be considered elsewhere (CANCER).

It remains to describe briefly those varieties in the characters of ulcers which depend on local or other non-essential conditions. Many of these, as already stated, have suggested names by which, as if they were specific distinctions, ulcers are often called and classified. These names may be respected if used in subordination to such as may imply the conditions on which, more essentially, the several forms of ulcers depend.

Varicose ulcers are such as are connected with an enlarged or varicose state of veins. They are found almost exclusively on the lower extremities, and especially on the lower half of the leg. The connection of ulcers with varicose veins is far from uniform. In some cases it is scarcely more than an accidental coincidence. A patient with varicose veins may have an ulcer of specific origin and form, and its characters and progress may be no further affected by the disease of the veins than so far as that disease is a hindrance to the circulation. Generally, too, the more evidently specific the ulcer, the less is it modified by the disease of the veins. In other cases, an ulcer has its origin in inflammation of a varicose vein, beginning in a patch of skin which is inflamed, and suppurates over a varicose vein that is hardened, and probably filled with clot. And, in yet other cases, the defective movement of blood through varicose veins appears to favor greatly the occurrence and ill progress of that low inflammation of the integument in which ulcers are most prone to form. This is especially the case in patients in whom the disease of the veins involves, not the larger subcutaneous trunks and branches, forming tortuous and convoluted thick-walled canals and clusters of veins, but the smaller cutaneous veins, which, in their dilated state, appear turgid and stellate near the very surface of the skin. Of the two forms of enlargement of veins, often coincident, yet not rarely seen apart, this latter is by far the worst concomitant of ulcers of the integuments. It is through this, especially, that so many of the most painful inflammatory and eczematous ulcers at the ankles are described as beginning and always aggravated in pregnancies ; through this that such ulcers are apt to become chronic and callous ;

and through this that, in advancing years, the healing of ulcers at or near the ankles is so slow and insecure.

Although, as already stated, any ulcer may be complicated with varicose veins, yet they are most commonly found with the inflammatory and eczematous and chronic. And with all alike, the remedy of the defective circulation is essential to a speedy and secure recovery. Constant recumbency, and elevation of the limb, are the simplest means to this end ; but with many patients they are the least possible. Their best substitute, and that which is usually necessary for after-treatment, is regulated pressure with bandages, strappings, elastic stockings, or the elastic spiral band ; the materials for the strapping, whether wet lint, plaster, ointment, or any other, being determined according to the character of the ulcer. Special skill in bandaging may be rewarded with the greatest success in the treatment of varicose veins, and may often dispense with rest and recumbency. The obliteration of the veins, by any of the means that will be described in the appropriate essay (DISEASES OF VEINS), may also be advisable, especially in the case of chronic ulcers. And the complication of diseased veins increases, if possible, the necessity of improving defects of the general health ; every unnecessary hindrance to the circulation in any part should be removed, and every help given to insure a normal excretion, and full action of the heart. Among all medicines for this class of cases, iron appears to be the most effective ; there are comparatively few cases of "varicose ulcers" in which it is not beneficial, and it is most so when the smaller cutaneous veins are involved. Opium, also, is of value ; most so when the ulcers are most chronic.

Œdematous, or weak ulcers. — These terms have been somewhat vaguely used, but are best and most often employed for ulcers whose granulations are upraised, pale, translucent, soft, easily breaking, such as those usually are which are connected with scrofulous bones or joints. Except in connection with well-marked scrofula, or with disease of deeper textures, such ulcers of the integuments are not frequent. They may occur on an œdematous limb, the granulations partaking of the general serous infiltration ; but more commonly they owe their peculiarity to their granulations being constricted by surrounding skin or scar. In the former case, the remedy, or rather the reduction of the ulcer to a more common form, depends on the curability of the general œdema ; in the latter, it may be effected by nitrate of silver, or astringents, as sulphate of zinc or of copper, or by dry pressure.

Exuberant ulcers.—Ulcers are sometimes seen, especially on the feet and hands, which, without any apparent cause, exhibit an excess of granulations. Their granulations rise prominent beyond the adjacent skin, and overhang it, and are not œdematous, but as florid and compact as those of a healing ulcer. Escharotics, or pressure, or both, will cure this peculiarity. Till its origin be known, its chief interest may be in the likeness which it sometimes bears to the exuberance of ulcerated cancer. The diagnosis may rest chiefly on the feeling of the granulations : the cancerous are hard, or at any rate very firm, and fixed on a hard basis ; those that are merely exuberant are not hard, but soft, fleshy, easily yielding to pressure.

When speaking of these ulcers with outgrowing granulations, it may be well to note that when an ulcer or fistulous canal opens into a synovial cavity whose lining membrane is in the state of so-called pulpy degeneration, an exceedingly exuberant growth of granulations may ensue, with an appearance of eversion of the synovial membrane through the ulcerated opening. Hence the remarkable aspect of certain ulcers connected with diseases of joints and sheaths of tendons—fungous ulcers, as they are sometimes called.

Hæmorrhagic ulcers constitute no distinct class, and their diagnosis and treatment must depend on other things than the mere bleeding. Some ulcers bleed, being vicariously catamenial ; some through excessive venous fulness, or the bursting of a subjacent varicose vein ; some, as phagedænic or sloughing, through extending into some bloodvessel ; some, especially the cancerous, or those that are connected with ulcerated tumors of any form, through the giving way of thin-walled new vessels ; some, because of the existence of scurvy or the hemorrhagic diathesis.

Neuralgic or irritable ulcers.—The pain of some is so great and so disproportionate to all their other symptoms, that they may deserve one of these as a subordinate name. The pain of some examples of inflammatory and eczematous ulcers has been already mentioned, and is unexplained ; so is that of many ulcers connected with small varicose veins ; but the type of ulcers, whose pain having no satisfactorily proved cause may be called neuralgic, is in those small, flat, oval, or circular ulcers that occur at the margin of the anus—the so-called irritable ulcers or fissures of the anus. These show well how very little power any sedatives, locally applied, have to subdue the pain of ulcers. The only remedy is in the cure of the ulcers, whether by section for those at the anus, or by whatever means might be re-

quired for ulcers of the same kind not attended by unusual pain. Nitrate of silver, for example, will do more to assuage a neuralgic eczematous ulcer than any opiate application. It is, indeed, remarkable that when such ulcers are brought to healthy granulation they are scarcely painful, and their scars are not more sensitive than those of any other form.

[It was Mr. Hilton's belief that the special irritability of these neuralgic ulcers is due to "the exposure of a nerve on the surface of the ulcer," the sheath of the nerve having been destroyed and "the end of the true nerve fibre remaining denuded." Admitting the correctness of this view (and that it is very often correct there can be no question), it can readily be understood why section or the application of some coagulating agent, such as nitrate of silver or carbolic acid, will afford relief.]

Inflamed ulcers.—Any ulcer may become accidentally inflamed. The signs of this event are, increased pain in and about it, a diffuse redness, or a brighter redness of all the adjacent skin, with more or less of œdema, a more copious discharge, thinner and often tinged with blood, and swelling of the granulations, with mottled, ruddy, and tawny colors, or with partial sloughings of them. Commonly, too, the edges of the ulcer look more abrupt and jagged than they did, and extend more rapidly. The popular expression, "angry looking," figures very well the aspect of

[Fig. 67.

Inflamed ulcer beginning to heal. (Gross.)]

the inflamed ulcer. The remedy for this state is in some such treatment as the same patient might require for any other inflammation. Rest, elevation of the seat of the ulcer, the removal of local irritants, water-dressing, poultices, generally suffice for local means, or leeches may be applied; while the general treatment is to be decided by the general condition of the patient. For at least one variety of ulcers—the chronic or callous—an active inflammation is often beneficial, inducing changes which are followed by a more rapid healing.

The chronic, indolent, atonic, or callous ulcer has some of its chief characters told by these names. It is rare on every part except the leg, most frequent on its lower

[Fig. 68.

Foul indolent ulcer. (Gross.)]

half; of uncertain size and shape, but most often oval, with its long axis parallel with that of the leg, or, when very large, encircling the leg. Its base usually lies deep, and is flat, pale, or tawny and dusky, with very minute or no visible granulations, compact and nearly hard, and adherent to the fascia beneath it. The margin is usually abrupt, or unequally shelving, and, in its most characteristic form, "callous," thickly overlaid with opaque, white, dense epidermis, and having beneath this very enlarged papillæ. Both the margin and all the surrounding integuments, often for many inches distant, are thickened, hardened, "callous," sodden, as with a kind of very firm œdema, and adherent to the subjacent fascia. The surrounding cuticle, also, is often shining and scaly, or dusky with pigment. The ulcer itself is generally almost painless, unless accidentally inflamed; its secretion is a thin ill-smelling pus; its most frequent complication is large varicose veins higher up on the limb.

Any ulcer of the leg may become thus chronic and callous when it exists very long; and when a distinctly specific ulcer thus changes, it not only loses its specific characters, but ceases to be amenable to specific treatment. Thus, the more a ter-

tiary syphilitic ulcer becomes like a chronic ulcer, the less is the good influence of iodide of potassium upon it. But all ulcers are not equally liable to the change to "callosity;" the strumous are much less so than the tertiary syphilitic, and the inflammatory and eczematous are more so than either. And although in general the peculiarities of the chronic ulcer may be due to a long-continued slow inflammatory process, probably attended with production of lowly-organized, interstitial, new formation, yet in some cases the complete characters of the ulcer are attained in three or four weeks. This is most likely to happen in elderly people, ill-fed, or cachectic, or with firm œdema about the feet and ankles, in whom ulceration is excited by any ordinary cause.

Through whatever course it may have passed, the chronic ulcer is usually amenable to treatment. It would be hard to enumerate all the means that have gained a reputation for curing it. Those which are certainly very good, and very rarely insufficient, are opium, regulated pressure, and blistering. Either of these, combined with rest, good food, and attention to the general health, will cure any but the very worst examples of chronic ulcer; and even in less advantageous circumstances, they will seldom fail. The doses of opium usually found sufficient are a grain night and morning; and the local treatment may be with stimulant ointments, such as that of the nitric oxide of mercury, or lotions of zinc or copper, or either of the following means. The regulated pressure is commonly and effectually applied with calico bandages or straps of adhesive or lead plaster on linen (on Baynton's plan), or, if the skin will not bear plaster, the strapping may be better done with linen wet with water or any appropriate lotion. [By far the best method of making pressure is by the application of the rubber bandage of Martin. In the great majority of cases the use of such a bandage soon produces much improvement; in many cases the result is a complete cure, and in only a comparatively few does there result such irritation of the skin as to compel a discontinuance of its application.] Blistering should have for its design not only, if at all, the stimulating the ulcer itself, but the softening and thinning of its callous edges and adjacent tissues, which it seems to accomplish by causing absorption of part of the exudation with which they are infiltrated, and desquamation of the cuticle with which they are cövered. With a similar view, a good auxiliary to any other mode of treatment is the scraping off the thick epidermis from the margin of the ulcer.

In the worst cases, when all these means fail, it is commonly because the base of the ulcer and the integuments surrounding it are so indurated and so adherent to the subjacent tissues, that they will neither stretch nor slide towards the centre of the ulcer, even when healthy granulations form on it and would contract in developing into a scar. To remedy this hinderance of healing, it is sometimes useful to make incisions through the integuments, near and parallel to the margins of the ulcer, so that the gaping of the incisions may give opportunity for the contraction of the granulations on the ulcer. [In this way, as also because of the local depletion consequent upon the incision, we may explain the production of the favorable results that at times follow the Nussbaum "girdling-operation;" a method of treatment, however, that may, and often does, do more harm than good.] In similar cases, transplantation of an adjacent portion of healthy integument, sufficient to cover in the ulcer, has cured it. In the worst examples, and especially in those in which a chronic ulcer forms a broad belt all around the leg, or in which such an ulcer over the tibia has excited thickening of periosteum, and formation of new bone beneath its base, and is firmly adherent to the structures thus changed, the healing, even if it be achieved, is so unsound that amputation, if not too dangerous to life, is advisable; and it should be done through healthy and mobile integuments; otherwise, the result will be an unsound stump.

Phagedænic and sloughing ulcers.—Nearly all the chief points of interest connected with the ulcers thus called will be considered in the essays on GANGRENE and SYPHILIS. Here it may suffice to say, that such rapidity of extension as may deserve to be named phagedænic is very rarely seen in ulcers, except in connection with syphilis, or hospital gangrene, or some similar condition. In acute inflammation, any ulcer may enlarge quickly; but the rapid destruction generally implied by phagedæna has a specific, and probably, also, an external source. Sloughing is a much more common complication of ulcers—sloughing, that is, not so much of their edges and adjacent parts as of their granulations. Thus, in inflammatory ulcers, the frequent appearance of a grayish or yellowish base is generally due to sloughing of granulations; so in senile ulcers, sloughing is very common; and in any form, in old persons, senile gangrene of the integuments around the ulcers may ensue. So, again, the whole base of a great chronic ulcer may often be seen sloughing, through injury, or defective food, or exposure to hard weather.

Such are the chief forms, principal and subordinate, of ulcers of the integuments,

of which sufficiently numerous instances may be seen to allow of their being described in general terms. A closer and more express study of the subject would certainly lead to the discovery of many forms which are not here indicated, because they are known to the writer by only a few instances, incompletely observed. The characters of ulcers, if more fully studied, both in well-marked and in modified and complicate examples, would be found as various, and, severally, at least as well-defined, as are those of cutaneous eruptions; and with the better diagnosis that would be thus attained, there might follow a much better discrimination of the means of treatment appropriate for each.

PART III.

INJURIES IN GENERAL.

CONTUSIONS.
WOUNDS.
BURNS AND SCALDS.
ANIMAL POISONS.
WOUNDS OF VESSELS.
FRACTURES.
DISLOCATIONS.

PART III.

INJURIES IN GENERAL.

CONTUSIONS.

By Sir James Paget, F.R.S.[1]

Contusions are the injuries, other than wounds and fractures, which are produced by blows or sudden pressures. The term may, as a surgical title, include all such injuries in their widest degrees of difference, from a simple bruise to an utter crushing of a part. It may include such injuries in internal as well as in external parts, but is commonly and will be here employed for only external parts, the contusions of the brain and spinal cord being included under concussions, and those of other internal parts being usually named ruptures or lacerations. The typical, being the most frequent, instance of a contusion is the common "bruise" of skin and subcutaneous tissue.

The states of parts recently contused may be studied in (1) their proper textures; (2) their bloodvessels and blood, and other extravasated or exuded fluid.

1. In the slighter degrees of contusion the textures suffer only a concussion, shaking, or jarring; a disturbance which may produce no visible change, except the effect of the rupture of bloodvessels and effusion of fluid. Thus it is in ordinary slight bruises.

In severe contusions the damaged structures are broken; there may be visible ruptures of muscles, bloodvessels, and other soft parts; splittings of the connective tissue between adjacent structures; and, especially, splittings of the subcutaneous tissue, and separations of it from the fasciæ, or other parts beneath it. These last-named injuries are, perhaps, the most common of those produced by heavy blows, and are those to which the chief external signs of severe contusions are due.

In the extreme degrees of contusion, the parts are thoroughly crushed. In a part thus damaged, the muscles and other soft parts may be so broken and crushed that, with the extravasated blood, they make a mere pulp; and such parts as hold out and look entire, among which the skin, nerves, and tendons are most often found, are yet damaged beyond recovery, and perish in the gangrene which is the usual result of these extreme injuries. In crushings such as these, even the elemental structures of parts may be broken, and minute fragments of muscular fibres are easy to find among the materials of the pulp.

2. The injury done to bloodvessels in contusions is very difficult to ascertain. Sometimes ruptures of vessels are visible, but more often the extravasation of blood is the only evidence of the existence or extent of such rupture. And this evidence is not exact; for, with the blood, there is more or less of blood-stained fluid, the diffusion of which makes the extravasation appear greater than it is.

Other things being equal, the quantity of blood extravasated would depend on the size and number of the ruptured bloodvessels. But many things make the quantity vary. The more lax the textures of or adjoining the injured part, the more copious the extravasation; witness the bruises on the eyelids, scrotum, and labia. The constitution of the patient has much influence. In scurvy, and the so-called hemorrhagic diathesis, even slight blows may produce serious extravasations of blood; and many persons, especially pallid, fatty, soft-skinned women, though suffering with no evident

[1] This article has been, upon careful revision by Dr. William Hunt, found to need no addition or correction.

disease, are subject to extravasations very disproportionate to the injuries that cause them. As they say, "the least touch bruises them."

The escape of blood and the effusion of serous fluid in a contused part may cease in a minute, or less; or it may continue for two or more days, although there may be no reason to believe that a large bloodvessel is ruptured. Thus in children, a blow on the head may be followed by a swelling, which will slowly extend over the whole forehead, or vertex; and a crushed leg or thigh may continually swell at the injured part, and become more and more tense with subcutaneous and intermuscular extravasation and effusion. In rare cases, even many days after contusion with extravasation, a fresh bleeding may ensue, such as might be called secondary subcutaneous hemorrhage.

The blood extravasated is of dark venous color, or becomes so while stagnant in the tissues: but it may be brightened in parts permitting the penetration of air, as in bruises of the conjunctiva, which are usually scarlet or bright crimson. The blood is commonly infiltrated among the structures of the injured part; or, many small clots may be scattered among them, with infiltrations of blood, and blood-stained, or variously colored, serous fluid; or, nearly all that is extravasated may be collected in one or more large clots, which may, after some long time, again become liquid;[1] or, perhaps, very rarely the extravasated blood, not clotting, may remain liquid in a cavity left by the separated tissues. The causes of these differences are unknown; the consequences will be considered hereafter.

The signs of recent contusions, which are most general and characteristic, are, some degree of shock, pain, swelling, and ecchymosis, or bruise.

The shock has in it nothing peculiar to this kind of injuries. Generally, and without referring to injuries of internal organs, it is proportionate to the amount of damage sustained. Complete crushings of small parts of the body, as part of a hand or foot, are usually attended with less shock than are less severe injuries of larger extent. Contusions of certain parts, moreover, as the testicles, the large joints, and the breasts, are often followed by remarkable feebleness of pulse, sensations of sinking, tendency to syncope and to vomiting, and great temporary loss of muscular power.

The first morbid sensation, after that which is felt at the blow, is, usually, a numbness of the injured part; and the severer the hurt, the longer this may continue. But, unless the part is killed, numbness gives place to pain, which is commonly described as of a dead, heavy, aching kind. In the muscles, the pain is attended with more or less loss of power, and is greatly increased when they are made to contract; in the nerves, it is attended with tingling, or sensations of burning, both at the place of injury and in their distribution; in the testicles and other parts above mentioned, the pain seems to be a chief cause of the more intense shock that accompanies their contusions. When only the softer structures are contused, the pain is not usually associated with much tenderness, it may even be alleviated by pressure and friction; but the contrary is more frequent in bruises involving periosteum and other fibrous structures, and those of joints. In these parts, also, the pain and tenderness are, usually, of much longer duration.

Swelling, generally, follows quickly the violence by which a part is contused. First, some depression or indentation may be seen, with softening of the injured tissues; but, by their elasticity, they soon recover from this state, and then are raised with more or less of swelling. One of the best examples of this swelling is the bump that so quickly follows a blow on a child's head. It is due partly to extravasation of blood, but much more, in ordinary cases, to the rapid afflux of blood, and exudation of fluid from the vessels, in the stricken part. The process of exudation is probably, in this case, the same as that by which a joint severely stricken is filled with fluid. A similar swelling from contusion, and attended with little or no extravasation of blood, is in the wheal that rises after a lash with a whip. In loose-textured parts, as the eyelids, this swelling is often considerable, and may remain for a week, or more; in other parts it usually subsides in two or three days, or less; and if later swelling ensue, it is probably due to inflammation of the injured part.

Ecchymosis, or bruise, when the consequence of blows or crushing of parts, is due to their being infiltrated with blood or blood-stained and serous fluids, of which the color is seen through the cuticle. These fluids cannot be collected from the tissues in which they are infiltrated, but can be seen tinging them; and are, doubtless, the same kinds of fluid as those which fill the vesicles and bullæ so often seen in the neighborhood of fractures (especially those of the tibia and ulna), attended with much contusion of soft parts. The common basis of all the diverse-looking fluids appears to be serum, nearly pure or with suspended blood-cells, and dissolved coloring-matter; and according to the

[1] Baker, in St. Bartholomew's Hospital Reports, 1867.

proportions in which these are present, so is its tint more or less deep and like to that of venous blood, or scarcely darker than healthy serum. Where very small quantities of coloring-matter are present, and the fluid is collected in widely-separated spaces of loose connective tissue, it may remain like the contents of a serous cyst. Such cases are sometimes described as "traumatic hydroceles," a name which would be not less ill-applied to the large vesicles over seats of fracture.

The colors of ordinary recent ecchymosis from blows are various shades of purple, tending on the one hand to black or blue, on the other to crimson or pink, and with these are mingled shades of yellow, pale brown, and green; dependent, apparently, on the quantity of effused serum and its mingling with fluids of other colors. Blackness, usually indicating intense injury, is probably due to the extravasation of a large proportion of entire blood; crimson or pink tints to the prevalence of blood-stained fluid; blue to the degrees in which blackness is veiled by the cuticle and skin, as the color of blood in veins is; and, perhaps, some of the shades of pink to the partial aëration of the blood, by the penetration of air through the epidermis.

After a variable time, proportionate to the severity of the injury, the darker colors fade out, and leave, or give place to, gradually lightening shades of brownish-olive, green, and yellow.

The changes usually commence at the borders of the ecchymosis, and thence proceed to its centre, but with so little uniformity that the commonest appearance of a fading bruise is motley.

The very changes on which some of these varieties of color depend are not known. They are not generally, if ever, observed in bruises of parts removed from air and light. In a limb with ecchymoses of all shades at its surface, those in the muscles, periosteum, and other deep-seated tissues, are either black, or crimson, or of some of those pinkish or yellowish tinges, through which blood-clots in vessels pass in their gradual decoloration; they are not blue, or olive-colored, or green. And in the ecchymosis of the conjunctiva, the scarlet of which contrasts strongly with the "black-eye" in the eyelids, the fading tint is usually only yellow.

The time at which an ecchymosis becomes externally visible after injury varies with the depth of the effusion. If it be at the surface of the skin, the ecchymosis may be almost instantly visible, or may become so in a few minutes. In deeper injuries, days may elapse, and the ecchymosis may then appear at some distance from the injury, and not directly over it, as it more commonly does; and may, from its first appearance, have only the paler green and yellow colors. In like manner, as if with gradual diffuse infiltration of colored fluid, a superficial ecchymosis may go on extending in all directions for many days; extending not only by wider diffusion but by continuous effusion of fluid from the injured vessels; just as the vesicles and bullæ over fractures may go on for several days increasing in both size and number.

The foregoing observations on ecchymoses relate to cases in which blood and bloody and serous fluid are infiltrated, and in which they are not perceptible to the touch. When the blood is all in one clot, or in a liquid state inclosed in a cavity, there may be no visible ecchymoses, or only some around the extravasated blood, but the blood may be detected by the touch. When liquid, and among soft parts, it may be felt as a fluctuating swelling, usually very soft and flaccid, like liquid in a half-empty bladder. When thus extravasated over bones near the surface (as those of the vault of the skull), the blood commonly feels like a circumscribed swelling, soft at its centre, hard at its border; and the depth to which the centre may be pressed in often makes it seem as if the bone were depressed. But, with the deepest pressure, the bone may be felt at its right level. In many of these cases, too, the blood pressed to and fro gives to the fingers a peculiar vibratory sensation (called, by some, crepitation), like that of fluid in certain bursæ and sheaths of tendons.

When contusions are not complicated with other injuries, and when the hurt parts do not slough or inflame, their effects usually terminate with the absorption of the extravasated fluids, and the recovery of the tissues from whatever injuries they may have sustained. The repair of the tissues is usually so complete that, after even severe contusions, such as those which accompany fractures, no traces of their injury can be seen. The liquid parts of the blood, when infiltrated, are generally absorbed quickly. The blood-cells and other materials of clots are very slowly removed. I have found the blood-cells, in the little ecchymoses of leech-bites, unchanged a month after their extravasation, and small clots and diffused blood in the neighborhood of simple fractures scarcely changed at the end of five weeks. The larger the clot, the slower is its removal; and the extreme of slowness is found in the collections of extravasated blood that remain or become wholly or in great part liquid. In these cases, which are most frequent in contusions of the loins, nates, and other parts with extensive and loose subcutaneous tissue, the blood may remain for many weeks with

apparently little change. If let out, while recent and liquid, it will generally coagulate like ordinary blood; if left, it may be gradually absorbed, or, decomposing, may excite active inflammation. The boundaries of the space in which blood is thus long retained may become firmly defined, and cyst-like; capable, perhaps, of secreting serous fluid which may mingle with the blood within them; certainly capable, after inflammation, of granulating and assuming all the characters of the walls of an abscess.

There is sufficient reason to believe that blood extravasated in a contusion may be organized; acquiring the characters of connective tissue, becoming vascular, taking part in the repair of the injured tissues, or in the thickening and induration that remain when the repair is incomplete. For although, so far as I am aware, this process has not been traced after simple contusions, yet evidence of it may be found in blood extravasated near fractures, in the clots in tied or injured vessels, and in not a few other instances. Nevertheless, it is not probable that this organizing of blood is frequent after contusions; and the more exact the researches that are made, the less reason is there found to adopt the belief that blood extravasated in a contusion can become a tumor of any kind. Contusions are, indeed, sometimes followed by the growth of tumors, but the event, if we compare its frequency with that of contusions, might almost be called infinitely rare; and there is no instance in which any of the stages of transition have been traced between the materials of extravasated blood and those of a cancer or any other tumor. It may be added that, even if such transitions could be traced, a yet greater difficulty would remain unexplained, namely, the power of continuous growth possessed by the new materials.

In some cases, especially when the contusion is severe, or the extravasation very large, or the general health of the patient unsound, the contused part becomes actively inflamed; the blood appears to act as a foreign body; probably, being mixed with the products of inflammation, it dies; and the usual result is, that it is ejected with suppuration. The abscess-cavity (as that which contained the extravasated blood has now become) generally continues, for many days, to discharge blood-stained pus; but at length it assumes the ordinary characters and progress of a common abscess. The probability of suppuration ensuing is greatly increased, if the contusion be accompanied with an external wound, however small. Indeed, the existence of such a wound commonly makes the same difference in the progress of a contusion as in that of a fracture; a difference sufficiently important to justify the use of the name "compound ecchymosis" with meaning similar to that of compound fracture.

Sloughing, as a consequence of contusion, has been considered in another place (GANGRENE, p. 357.)

Complete recovery, as already stated, is the ordinary termination of contusions. Yet certain prolonged, or permanent, ill consequences may be not rarely noticed. Sometimes the injured subcutaneous tissue hardens and contracts, forming a kind of subcutaneous scar, marked by a dimple in the skin. In some organs (chiefly the breast and the testicle), abscess may ensue long after a bruise; more often an indurated lump remains, consisting apparently of hardened and contracted gland-tissue, and often exquisitely sensitive. Still more commonly, a blow on the breast is followed by long-continuing pain and tenderness, without change of texture. Blows on the skull and other superficial bones are sometimes followed by persistent, circumscribed, and very painful thickenings of the periosteum. A muscle violently struck may be paralyzed, and then may rapidly waste. A nerve similarly injured or crushed may remain paralyzed, or become the source of extreme pain, or other morbid sensations. And any contused part is likely to become the seat in which any constitutional disease present at the time of, or soon after, the injury will localize itself; witness, the apparent election of bruised joints or muscles for the local attacks of gout and rheumatism, and of bruised bones for syphilis or struma. Even smallpox will be more thickly confluent over a recent bruise than over any other part. Probably, the growth of cancerous and other tumors in bruised parts belongs to the same class of facts.

The treatment of recent simple contusions of the less severe degrees needs but few words. Left to themselves, in the quietude necessary for avoiding pain, natural recovery will ensue. But the clearing-up of the swelling may be hastened, and ecchymosis may be diminished or prevented, by certain stimulant applications, the best of which, except for gouty persons and those with very irritable skins, seems to be the tincture of arnica. When the skin is thick, this may be gently rubbed in on the bruised part, undiluted; with thinner skin it should be diluted with an equal quantity of water. Or, it may be applied constantly, as a lotion, if diluted with about ten times as much water. Other means for the same purpose, which have the testimony of popular reputation, are Friar's balsam, Riga balsam, and poultices made with roots of black briony beaten into a pulp. These, and all other local stimulants, such as the compound

soap-liniment, probably act by accelerating the circulation through the bruised part, and the absorption of the fluid on which the early swelling, and, in slight bruises, the greater part of the ecchymosis, depend.

In more severe and in complicated contusions other treatment may be necessary. In severe cases, with much breaking or crushing of the tissues, the parts should be kept warm, both for comfort's sake, and because cold, by further retarding circulation, increases the risk of sloughing, or of destructive inflammation. Wrappings with cotton-wool, or, better, with lint thoroughly soaked in oil, are among the best means; covering the part with warm poultices of linseed, or of linseed and bread, is perhaps as good. The design, however it may be fulfilled, should be, to combine rest of the injured part with uniform warmth and the exclusion of air.

The treatment of the extreme cases of contusion has been described with that of traumatic gangrene.

In cases of excessive effusion of blood from contusion, ice should be applied, and the injured part be raised, so long as there appears any tendency to increased swelling.

When the extravasated blood remains in large clots, or in liquid collection, friction and kneading will probably accelerate its removal by diffusing it in the surrounding parts; and, if need be, such treatment should be continued very long. If there seem, after very long treatment, no prospect of the blood being removed, it may be let out by puncture. A small puncture should be made, and if the blood be all liquid, it should be all removed, and the puncture closed, and the walls of the cavity compressed, in the hope that they may unite. If this fail, or if the blood be for the most part in clots, it is best to make a very free opening and let the cavity suppurate, and treat it as an abscess. But these means are very rarely necessary; in the vast majority of cases, the extravasated blood is naturally cleared away, even though its quantity may have been increased by secondary subcutaneous hemorrhage.

The inflammation that follows quickly after the less severe contusions rarely requires special treatment. That which ensues later, and is connected with changes in the clots, is so freely sure to end in suppuration, that it may be treated as for the formation of abscess; and the abscess resulting should be freely opened, and daily washed out, till all the blood-clots are removed. Thenceforward its course will be that of an ordinary abscess.

WOUNDS.

By Sir James Paget, F.R.S.[1]

Wounds are the divisions, or solutions of continuity, of soft parts, produced by external direct mechanical force. For systematic study they are sometimes classified according to their direction, or depth, or locality, but the most useful arrangement is based on the modes of their infliction. In this, they are divided first into open wounds, and subcutaneous; the former including those in which the outer part of the wound is at least nearly as extensive as that through the deeper tissues; the latter, all those in which the outer part of the wound is very small in comparison with the deeper part. In each of these kinds of wounds, but especially in the first, a further division is made into (1) incised wounds; cuts or incisions, including wounds of excision by which portions of the body are cleanly cut off: (2) punctured wounds; stabs, pricks, or punctures: (3) contused wounds, or those combined with bruising or crushing of the divided parts: (4) lacerated wounds, in which the division of the tissues is effected, or combined, with tearing of them. (5) poisoned wounds: including all into which any poison, venom, or virus is inserted.

Any wounds, of whatever class, may be either simple or complicated, *i. e.*, attended with excessive hemorrhage, or pain, or the presence of dead or foreign matter.

[1] This article has been, upon careful revision by Dr. William Hunt, found to need no addition or correction.

Many wounds, moreover, are such as cannot be precisely assigned to any one of these classes; for they have characters either combining or intermediate between those of two or more of them; but convenience of study will justify both the making of classes, and the description of typical specimens of each. The arrangement indicated above will therefore be here followed. The general part of the pathology and treatment of wounds will be included in those of incised wounds, because these have been most fully studied, and in their surgical relations are by far the most important. Then what concerns wounds of the other kinds may be much more briefly and specially described.

Simple open incised wounds are best exemplified by simple incisions made in surgical operations, or by accidental clean cuts with sharp-edged instruments. And three things, chiefly, are to be observed in them, viz., the opening or gaping by the retraction of their edges, the bleeding, and the pain.

Gaping of wounds.—The width to which an incised wound opens by the separation of its edges varies greatly in different tissues, and in different conditions of each. For a general rule, the order in which M. Nélaton[1] arranges the tissues, according to their respective degrees of retraction when divided, is sufficient—namely, skin, elastic tissue, cellular tissue, arteries, muscles, fibrous tissues, nerves, cartilages. But within this general rule are many particulars.

The retraction of divided skin depends on its elastic tension, on its muscularity, and on the state of the parts beneath it, and each of these may vary. The tension does so in different postures; as, when the knee is bent, a wound across the thigh gapes more widely than when the knee is straight. Generally, too, longitudinal wounds of the limbs and trunk gape less than transverse ones do. The retraction due to the muscularity of the skin cannot be distinguished, at first, from that due to its elastic tension, but soon after an incision, its effect is seen in the curling, or turning in or out, of the edges of the wound. Thus, in flap-amputations, the edges of the skin commonly become everted before the stump is dressed, while in wounds of the face, as for hare-lip, they rather become inverted. Probably, also, it is to the muscularity of the skin that that great retraction is due which sometimes takes place after amputations. For the influence of subjacent parts in the retraction of divided skin, one may compare a wound into the mammary gland, especially during lactation, with one in the sole or palm. The edges of the latter may remain nearly in contact, while those of the former may dispart till the width of the wound is nearly equal to its length. Examples such as these may suffice to indicate that although, as a general rule, a wound of skin will gape or retract more widely than that of any other structure, yet for good treatment every wound may require particular study.

The incisions for flap-amputations, or for tying deep arteries, will generally show how much less than the skin the deeper tissues, when wounded, retract their edges. Some structures, indeed, compressed by the retracting skin, appear to project from the wound; such as soft fat, and mammary gland; and these may illustrate the protrusion which sometimes happens when structures under firm pressure are exposed, through wounds in fascia or comparatively inelastic membranes. Thus, in penetrating wounds of the abdomen, portions of omentum may protrude and be tightly girt by the edges of the wound in the peritoneum, through which they are, as it were, buttoned. So I have seen the lump of fat on the buccinator tightly buttoned through a small wound in the interior of the cheek; and a similar protrusion and tight girthing of muscle or fat is probably a frequent cause of the troubles that follow penetrating wounds through strong fasciæ. The eversion of the mucous membrane of a wounded intestine through the opening in its peritoneum is an event of the same kind.

The retraction of wounded tissues, hitherto spoken of, is that which they display directly after division, and which is shown in the immediate gaping of the wounds. But, long after this, if they be not restrained, many of them continue to retract. Thus, in stumps that heal slowly, the muscles retract far, giving the conical shape; and arteries which, when first divided, may appear on the face of a wound, draw far away.

The bleeding from an incised wound depends, as to its quantity, on many conditions, chiefly, on the size of the blood-vessels divided, on their number in proportion to the extent of the wound, and on their connections with surrounding parts. Besides, the personal peculiarities of the patient, and the health or disease of the wounded part, may have great influence. It might be supposed that, at the instant after division, every vessel would bleed with a stream equal to its own calibre: but, when one watches how little, if any, blood flows from a wound except in distinct and visible streams, it seems evident that of the crowds of vessels that are seen in well-injected speci-

[1] Éléments de Pathologie chirurgicale, tom. i., p. 106.

mens of the tissues, nearly all must close during or instantly after their division. The mechanical irritation of the knife, probably, excites the muscular tissues of both arteries and veins to this contraction; and it is assisted, in open wounds, by the contact of the air; and in all wounds by the release of many of the capillaries and veins from the pressure of the blood, which ceases to be supplied to them in full quantity, when the arteries related to them are divided. Whatever hinders this contraction of the vessels prolongs and increases the bleeding. Hence the occasionally large bleedings from comparatively small vessels traversing, or connected with tough, close textures, such as the small arteries in or near aponeuroses and fasciæ, or in the more compact parts of the skin, *e. g.*, of the face. So, in inflamed parts, or in those near the seats of active disease; the dilated vessels bleed largely and long when divided, because of the loss of contractile power in their muscular coats.

Gradually, with or without surgical help. all the vessels divided by a wound are closed and cease to bleed; the larger being often aided to this end by their retraction among the looser textures, and by the coagulation of the blood within or over their orifices, and by the diminution of the heart's force with the increasing loss of blood. Coincidently, the flowing blood becomes gradually brighter and paler. And, if the wound be left open, after pure blood has ceased to flow, there is an oozing of blood-tinged serous-looking fluid; and this is gradually succeeded by a paler fluid, some of which collects, like a whitish film or glazing, on the surface of the wound. It contains very numerous white blood-cells, imbedded, apparently, in a fibrinous film. Its relation to the healing process will be considered hereafter (p. 391; and further, on bleeding see p. 400, and WOUNDS OF ARTERIES AND VEINS, and HÆMORRHAGE).

The pain of an incised wound cannot be usefully described, for it is so far peculiar that many of the terms applied to it can be intelligible to none who have not felt it. Sharp and cutting, at its infliction; then for a short time diffusely hot or burning; and then smarting till it gradually subsides into a feeling of mere stiffness—thus to describe it may remind those who have experienced it, but to others may teach no more than a description of colors to one who is color-blind. Besides, there are great differences in the degree, and perhaps also in the kind, of pain felt by different persons suffering with similar wounds. Some seem scarcely sensible; others, equal in fortitude, suffer most keenly. All suffer more, the more their attention is directed to the pain, and the more the mind has been sharpened by waiting and fear. An unexpected and unseen wound may be unfelt. There are also differences in both the kind and the degree of pain according to the place and manner of the wound. Thus, in regard to the skin, wounds of the face and of the extremities of the fingers and toes seem to be among the most painful; those of the back among the least so; wounds cut from within are less painful than those from without. The skin appears far more sensitive to wounds than any of the deeper structures, except the nerves of sensation themselves; but any part may become by disease, or distension, highly sensitive. A medical friend, who twice watched operations for inguinal hernia performed on himself, said that none of the pain surpassed that of dividing the tense fibres of the aponeuroses and the tight mouth of the sac. Periosteum, also, sometimes shows acute sensibility when cut; so do tightened tendons.

The consequences of incised wounds can scarcely be studied in man, free from the interference, for good or evil, of treatment. In some cases, indeed, even of large wounds, they are so trivial that they are unobserved; yet, after the majority of such wounds as are made in surgical practice, changes ensue, both local and constitutional, which are not necessary parts of the healing process, but rather hindrances to it.

The local consequences are characteristic of a certain amount of inflammation. In an hour or more after the wound (and, generally, the interval is the longer the more considerable the wound and the greater the shock), the edges of the wound, and the parts adjacent to it, become swollen and more sensitive; they feel hot and stiff, heavy or aching, and are more tender when touched; the sutures (if any have been put in) become tighter; and the edges of the wound, or of the spaces between the sutures, if not secured, gape open, because of the swelling and uprising of the subjacent structures. All these consequences of wounds may be best seen on the face; where, also, the chief cause of the swelling is often evident, in the serous-looking fluid by which the skin, especially of the eyelids, is puffed up.

In ordinary well-doing cases, these signs of inflammation continue from one to three or four days, and then spontaneously subside. The shorter their duration, the more perfect the healing. Their longer duration usually indicates disease, or some abiding source of irritation at the wound, and will be considered among the complications of wounds (p. 403).

Of the general consequences of wounds the first is the *shock*. In small incised wounds none may be observed; and when

in any case it does occur, it is scarcely possible to say how much depends on the wound itself, and how much on the circumstances in which it was inflicted, or on the pain and fear and loss of blood. But the whole of this subject is treated in another place (COLLAPSE).

Reaction.—The intensity of the shock commonly determines the time, and, in a less degree, the intensity, of the reaction which, in the ordinary course, immediately follows it. In some cases, indeed, even after severe wounds and much depression, the reaction does not go beyond the recovery of the natural standard of the heart's action and of other functions. The patient merely recovers, and may have no fever or other signs of general disorder; and the repair of the wound may make unhindered progress. But in far more numerous cases of considerable wounds, and especially in those that are not well closed, the reaction passes this normal limit: the pulse and breathing become more rapid, the former in a greater ratio than the latter, particularly when there has been much loss of blood; the pulse also is generally fuller or harder; the skin is flushed and feels hot; thirst is increased, and appetite lessened; the water of the urine is diminished; the bowels are inactive; the tongue usually white-coated, large, and moist; the sleep is short and often disturbed.

The duration of this state of feverish reaction or traumatic fever is variable, and bears no definite proportion to the severity of the injury; or, so far as is yet known, to any of the events connected with it. Not rarely, it subsides within twenty-four hours; more often, after large wounds (as those of amputation), it continues, with little diminution, for three or four days, and then gradually subsides; the pulse and breathing returning to their natural standard, the skin secreting more freely than natural, and becoming soft, and usually rather pallid and delicate in tint; the muscular power remaining less than natural. The commencement of suppuration in open wounds often coincides with the subsidence of the traumatic fever, but is no cause of it; for the same series of events commonly occurs where no suppuration takes place.

The continuance of signs of fever for more than four or five days after an incised wound argues the existence of some abiding irritation, or of some morbid state complicating the injury; but it is not usual for the common and almost normal traumatic fever to pass straightway into any worse form, such as that of erysipelas, or pyæmia. These may, indeed, ensue during the traumatic fever; but they more commonly occur at its close, or after it has subsided, or even in the period of convalescence. The liability to these specific diseases constitutes one of the most singular, and as yet unexplained, characters of the state of system following wounds.

The healing of open incised wounds may be accomplished in five methods, if we include those in which the process is assisted by treatment: viz., (1) by immediate union; (2) by primary adhesion, or union by the adhesive inflammation (both these methods are often named union by the first intention); (3) by granulation, or by the second intention; (4) by secondary adhesion, or the third intention, *i. e.*, by the union of granulations; (5) by scarring under a scab, the so-called subcrustaceous cicatrization.

Healing by immediate union consists in the simple conjoining or reunion of the wounded parts; no new material is formed to connect them; but being placed in contact and so maintained, they first merely stick together, and then become continuous.

The best examples of this mode of healing may be seen when flaps of skin have been raised by simple dissection, and then replaced on the subjacent parts; as for instance, in the removal of a tumor or a mammary gland. Within three days, or, in small wounds, within one day, the union may be complete, and little or no trace may appear of the line or plane at which the parts were separated. The process is so simple that it is best described by negatives. No sign of inflammation is observed; no evident afflux of blood; no evident production of reparative material; no scar; and no other conditions are required for the process than coaptation of the wounded surfaces, and the absence of inflammation at them.

Healing by primary adhesion, or adhesive union, is best seen in the cut edges of skin when they are brought near or into contact, and so maintained; *e. g.*, after the operation for hare-lip, or after plastic operations. Sometimes, indeed, such wounds heal, at least in part, by immediate union; but more commonly, as the formation of a scar testifies, they are united by a new material, lymph, the product of adhesive inflammation.

The lymph in this method of union being formed on both the cut surfaces, and probably exuding or growing alike from both, combines them. Very little, if any, is infiltrated beneath the surfaces. Appearing to the naked eye as a ruddy or a pinkish-white, soft, and adhesive substance, it shows with the microscope cells like those of granulations, in their several stages of development. As it organizes itself and becomes vascular, receiving bloodvessels from both the cut surfaces, so it gradually more and more firmly connects them; and it ends by forming be-

tween them a layer of connective tissue, covered with thin shining cuticle.

The first portions of this process, extending to the time at which the lymph becomes vascular, may be accomplished within forty-eight hours. In the case of small wounds the process begins almost immediately after their infliction ; in that of large wounds, a period of rest or inaction intervenes, of which more will be said presently. The later parts of the process are comparatively slow ; and at the distance of a week or more from the infliction of the wound, if anything tends to separate its edges, the lymph that unites them, being still soft though very vascular and not unhealthy, will suffer gradual elongation and attenuation till it may finally give way.

Healing by granulation may be exemplified by any incised wound left open and kept moist. Such a wound becomes, as already described (p. 389), coated, or, as it were, glazed over with a whitish film, containing abundant white blood-cells. If the surfaces of a wound thus glazed be brought together, they will unite, the film probably becoming organized and forming part of the bond of union. If they be left open, the film increases, so as to form a thin grayish or yellowish-white layer, which takes part in the formation of granulations.

But before granulations form, a period elapses, varying from two to ten or more days, according to the extent of the wound and the tissues involved in it, in which no visible change occurs in the injured parts. Probably, during this period of incubation, as it is called, the blood is stagnant in the vessels for some little distance from the wound ; and the renewal of its streams, and their increase in size, by such an afflux as ensues in inflammation, constitute the first visible step in the healing process. The change in the supply of blood may be best seen on the margin of cut skin, where it commences in from two to four days after the wound ; or of bone, where it commences in cancellous tissue in about a week, and in compact tissue in ten days or more.

The first appearance of granulations, which may commonly be seen in less than a day after the appearance of increased vascularity, is that of a layer of soft adhesive white or pale-pinkish substance on the surface of the wound. In another day or less, this may become vascular, with bloodvessels growing into it from those of the subjacent parts, and then, while it gradually increases to about a line in thickness, it acquires all the characters of granulations — a bright ruddy substance, soft, elastic, easily broken, succulent and abundantly vascular, granulated on its free surface, and at its attached surface intimately united with the tissue on which it is placed.

In minute structure, the new-formed granulations consist of cells, like those of inflammatory lymph, heaped together without apparent order, and connected by very little intermediate substance. Bloodvessels with walls of simple membrane extend into the cellular mass from the subjacent tissues. The largest vessels pass in lines directed nearly straight towards the free surface of the granulations, communicating on their way by many branches, and ending near the surface in loops or arches.

The further stages of the healing process consist in the gradual development of the substance of the granulations into those of a scar, *i. e.*, into fibro-cellular or connective tissue, and a superficial layer of epithelium. The former is developed progressively from the deeper to the more superficial part of the layer of granulations ; the latter, from the borders to the centre. With the progress of this development, the layer of granulations becomes paler, drier, thinner, and less vascular ; and as the epithelium forms on it, it becomes smoother, and changes its ruddy tint to a dim purple or pink.

The completion of the healing, whether by adhesion or by granulations, is attained by the gradual improvement of the scar ; the connective tissue becoming more and more like that of original formation, both in its own elemental structures and in the paucity of bloodvessels, and the cuticle becoming thicker and more opaque. Both structures, also, acquire characters adapted to the particular positions that they occupy. Thus, the scars of healed muscles and tendons are much tougher than those of healed skin : the latter, also, commonly acquire at length elastic fibres, and the cuticle of each scar becomes like that of the adjacent skin ; and, even beyond this, improvement continues in the gradual loosening of a scar from its adhesions to surrounding parts. This is effected, chiefly, by the changes ensuing in the tissue of that part of the scar which is subcutaneous, and which gradually becomes looser, less tough, and more occupied with fat.

During the whole period of the development of granulations, and the perfecting of the scar, a process of contraction goes on which greatly accelerates the healing. Thus, if the healing of a stump be watched, the healthy skin may be seen drawn in and puckered before any cuticle is formed on the granulations, unless at their very margin ; or, after the removal of any portion of the scrotum the diminution of the granulating surface is evidently due more to its own contraction than to the

formation of epithelium on it. By the same continued contraction new scars become gradually more depressed, and shorter, and draw more closely together the parts that they unite.

Again, while granulations are forming, and till they are covered with cuticle, or "skinned over," pus is constantly being produced on their free surface. The earliest exudations flowing from open wounds are albuminous liquids, nearly clear, viscid, ready to dry into adhesive scabs, and containing comparatively few cells. The gradual transition to the characters of genuine pus indicates a corresponding progress in the formation of granulations, and thenceforward their characters are mutually indicative. Healthy and developing granulations always produce, and are indicated by, normal pus; *i. e.*, by pus which is creamy, opaque, uniformly liquid, yellowish-white, and sufficiently abundant to cover completely the whole surface of the granulating wound. On the other hand, all defects and diseases of granulations are attended with morbid characters of pus.

Healing by secondary adhesion, or, as it may be called, by the third intention, is accomplished by the union of two granulating surfaces (*e. g.*, those of two flaps granulating after amputation) placed and maintained in contact. In this state the two surfaces simply unite, or else new material, produced from either or both surfaces, adheres to both, is organized into continuity with both, and thus unites them. The two layers of granulations thus form one layer, which, however, having no free surface, produces no pus, and is gradually developed into connective tissue. The process is very similar to that of healing by primary adhesion; but in that the lymph on the cut surface is not developed into granulations before the union. All granulations, however, will not thus unite; they must be healthy, not like those of sinuses, not profusely suppurating, not exuberant or œdematous.

Healing by scabbing, or under a scab, is the most natural, and, in some cases, the best of all the healing processes. Very commonly, in animals, if a wound be left wide open, the blood and other exudations from it dry on its surface, and, entangling dust and other foreign bodies, form an air-tight and adherent covering under which scarring takes place, and which is cast off when the healing is complete. The exact nature of the process has not been watched; but it seems to consist in little more than the formation of cuticle on the wounded surface, and it has the advantage that, as no granulations are produced, there is little or no contraction of the scar. In man the same process is less frequent; it is more apt to be spoiled by inflammation producing exudations under the scab, which either detach it or prevent the healing of the surface beneath it. Sometimes, however, the blood shed from a wound coagulates and dries on it, and remaining as a scab, permits healing under it; or, if this do not happen, a similarly effective scab may be formed by the serous fluid or lymph by which the surface of an exposed wound usually becomes glazed; or, more rarely, the pus of a granulating wound may scab, and sound healing take place beneath it.

Such are the several modes of healing of simple incised wounds, using them as a type of all open wounds. But, before speaking of the treatment by which each mode may be favored, it may be well to indicate the nature of the processes engaged in them.

Nature of the healing processes.—After every wound there is some tendency to an inflammatory process; and in general this is the greater the larger the wound, the longer its exposure to the air, and the greater the violence with which its infliction is accompanied or followed. This tendency to inflammation may not proceed beyond an increased sensibility of the part and an increased supply of blood. There may be no inflammatory exudation or formation, and where this is absent there may be the best healing. Or, where the inflammatory process goes on to the production of lymph, there it may cease; and the sooner it does so, the better for the healing.

Thus, in healing by immediate union, inflammation is a hindrance, if it proceed to exudation or proliferation; for no new material is required; the divided parts should simply and directly reunite; and if any inflammatory product be formed between or near them, it either retards, or, at the best, does not assist their union.

In healing by adhesion, an inflammatory process ensues, and may generally be regarded as necessary for the production of the new reparative material. But it should not go beyond this; its continuance is a hindrance to that organization of the reparative material which is essential to complete adhesion.

So in healing by granulation. If inflammation be present (and the lowest degree of it is best), it is only for the production of the first material for granulations. Their organization and continued healthy formation are retarded, or completely prevented, by any persistent inflammation.

For healing by secondary adhesion, and for that with scabbing, the absence of inflammation is essential.

The treatment of incised wounds may be guided in some respects, by these consid-

erations. As a general rule, nothing should be done by which inflammation may be excited or increased. So much as may be useful for some of the modes of healing will ensue through the violence of the wound itself; more than this can be only mischievous. On the other hand, the inflammation that directly follows a wound very rarely requires any express treatment, except in the case of organs in which even a transient inflammation may be productive of serious mischief, such as the eye, the large joints, the peritoneum, the lung, and other internal parts. The treatment of wounds of these parts will be considered in separate essays; but it may be here observed, that the occasional (and it is only occasional) necessity of active treatment after their wounds has no bearing on the question of the treatment of wounds in general; since such active treatment is designed, not for the healing of the wound, but for the safety of the part which it involves. Speaking here of only the general treatment of incised wounds it may be repeated that a primary traumatic inflammation, *i. e.*, such an one as ensues within the first day after a wound, needs no antiphlogistic treatment of any kind. It will spontaneously subside, and do less mischief than the intended remedy might do. The same may be said of the inflammation which may ensue or increase three or four days after large wounds, previous to the production of granulations. It will subside with their formation and the production of healthy pus, and needs no other applications than are comfortable to the patient. If inflammation should persist at a wound, or be renewed during its healing, it is almost certainly due to some of those complications of the injury which will have to be considered in another place (p. 403).

In the treatment of all wounds the position of the part is of some importance. The chief rule concerning it is that it should be such as can be maintained long enough without great discomfort. No other advantage can compensate for the loss of rest, and the general illness, that are produced by painful postures of injured parts. When comfort has, as far as possible, been secured, the next objects should be that the wounded part should be relaxed, so that the edges of the wound may come near or together; that no part, and especially no muscle, should be on the stretch; and that the direction of the wound may be such as will allow fluids to flow away from some part of it. If these conditions cannot be obtained by any position of the wound, various methods of padding and of bandages may supply them; but these should never be resorted to unless it is clear that position alone will not suffice.

The particular treatment of simple incised wounds must depend, in great part, on the mode of healing which it is intended to promote. There are, indeed, comparatively few wounds of the kind, in which the healing by immediate union or by adhesion is not desirable, and worth attempting. The following are among the few: namely, wounds through many different structures, and exposing considerable surfaces of deep-seated bones, *e. g.*, wounds for the removal of exostosis of the femur or for the ligature of some of the great arteries; deep wounds whose depth much exceeds their length, *e. g.*, many of those that go through the mammary gland for the removal of deep tumors; wounds of which the sides or their deeper portions cannot be brought into good contact; wounds through acutely inflamed or otherwise very diseased parts; and those from which secondary hemorrhage is likely to take place. Excepting these, there are very few incised wounds in which the simple and speedy modes of healing may not be attempted. Even with these exceptional cases, judicious padding may often prevent the chief evil to which the wounds are prone, namely, the collection of blood and other fluids under the closed integuments: and the mischief that may arise from the collection and decomposition of such fluids may be averted by the sponging of all the wounded surfaces with strong solutions of chloride of zinc, after the manner of Mr. DeMorgan. Or, again, in many of the wounds that are least favorable for union, a partial speedy union may be safely obtained, by leaving a portion of the wound open for fluids to drain through while the rest is closed. It is often advisable to adopt this method in the healing of large and deeply cut stumps, or of large excavated wounds in any part.

Treatment for primary union of wounds.— If the healing by immediate union or by adhesion be designed, the following are the chief things to be looked to: the arrest of bleeding; the cleaning of the wound; the exact apposition of its edges; their maintenance in this position; the exclusion of the whole wound from the air.

For the *arrest of bleeding*, if there be considerable vessels, they must be tied, twisted, acupressed, or crushed at their ends. But all these means, and especially ligatures, are hindrances to exact and close union, and should be avoided unless for the arrest of bleeding which is likely to be really injurious. Small vessels will spontaneously cease to bleed if exposed to cool air, or when the edges of the wound are pressed together; and such spontaneous closure is more favorable than any other to speedy healing. It is desirable for the security of such healing that the

surfaces of the wounds should be completely clean of blood when they are brought together; but it is not essential that they should be so. The less blood there is on them, the better; all clots and liquid collections of blood should be carefully removed from them; but it is not essential to stay from putting up a wound till not a drop of blood can be seen to flow; and it is not commonly advisable to do so, unless a renewed and increased bleeding is to be expected. Of the numerous means for arresting bleeding from small vessels, those which are least hostile to speedy healing are, cold air, water applied either to the wound or to its immediate neighborhood, and pressure with dry lint.

The cleaning of the wound from all foreign matter should be complete; but, like all other proceedings for good healing, it should be accomplished without violence. Wounds should not be scrubbed even with sponges; they may be best cleansed with streams of water.

For the *apposition of the cut surfaces and edges* of wounds the chief means are, the various methods of padding and bandaging; sutures, and adhesive plasters. Of these, the first are adapted chiefly for the union of the deeper parts of large wounds, especially of the limbs and head; the others, for the more superficial parts of nearly all wounds.

Pads may be usefully employed in many wounds attended with excavation; as, in amputations of the breast or removal of axillary glands, or in some flap-amputations. Their utility is in securing the contact of those parts of wounds which are out of the reach of sutures, and which would be partially, if at all, compressed by plasters. They should be made of cotton-wool or lint, or felt, fitted according to the necessity of the case, and retained in place by rollers or plaster, or many-tailed bandages.

Sutures, the modes of applying which are described in the part on MINOR SURGERY, find their chief utility in the union of integuments, and for this are valuable far beyond all other methods. The quilled suture is applicable to deep wounds; but is scarcely used except in plastic operations in the perineum. The twisted suture has its special value for wounds through the lips and cheeks; for some wounds into joints and the abdominal cavity. The uninterrupted suture, again, is adapted for only a comparatively few wounds; namely those of the intestines and eyelids, and the superficial wounds of the palm and sole, in which the suture may be carried through the epidermis alone. The interrupted suture has no such narrow range of utility. Alone, or together with pads and bandage, or as complemental to the quilled and twisted sutures, it may be used for the union of all wounds for which speedy healing is desired. If there were any well-grounded objections against sutures of coarse silk or thread, they do not exist against those of metal, or of very fine silk, or thread, or horse-hair.

Except for very superficial wounds, plaster (with which may be arranged collodion and other similar materials) cannot be relied on for immediate or adhesive union. In other cases, its chief value is for supporting and compressing the deeper parts of wounds, and for bringing together the parts intermediate between sutures.

Coverings of wounds.—A simple incised wound, when its sides are thus brought into complete contact, may be left uncovered. But, in general, some covering is advisable for even the simplest wounds; and none is better than lint soaked in oil, and placed over the whole length of the wound, or over it and all the immediately adjacent parts. Wet or dry lint, however, may be used with little less advantage; or simple cerate on perforated linen. Whatever is used should be light, not adhesive, not ready to undergo or to favor decomposition, but sufficient to protect the wound from friction, dust, and sudden change of temperature.

The condition of exclusion of the wound from air may be, by these several means, sufficiently fulfilled for the speedy healing of most wounds. For some the method of Mr. Lister may be used: closing them from the air and preventing the evils of the admission of organic germs upon which the decomposition of the fluids may depend, by covering all the wound and adjacent parts with carbolic acid.

No general rule can be stated respecting the time at which any, or the whole, of the dressings should be removed from a wound intended for healing by adhesion or the immediate union. In small wounds about the face, union may be complete and close in two days; but it is never so firm as to be safe from probable accidents; and it is among the chief advantages of metallic or fine thread sutures that they excite so little irritation that they may be left in their places for any time requisite to make the union secure against all probability of failure. It is, therefore, rarely advisable to remove them or any part of the dressings, unless it be the outer covering for cleanliness, before the lapse of four days, and for large wounds they are better left for seven or more; since, even when there is tendency to retraction of edges, the sutures will restrain and limit it, without doing any damage. Even when, with this retraction or tension, they "cut out," they do no harm. In short, they may be kept in

as long as there is any hope of obtaining either primary or secondary adhesion, provided they do not prevent the escape of pus or other exuded or decomposing fluids.

If, at the first dressing, the union or adhesion of the wound be in good progress, the rules for later dressings may be few. Whatever sutures are removed (and it is seldom proper to remove all at once) should have their places taken by strips of plaster or of lint with collodion; the union, or the scar, should not be cleaned too scrupulously; it should be protected even from the plaster with oiled lint; and should be touched, if at all, as gently as an embryo—for such it is. The daily, or less frequent dressings of the part may be made in the same general manner; and, if all has gone well, the union of small wounds may be deemed safe at the end of a week, and that of larger ones at the end of ten days or a fortnight. But, to the last, recent scars are subject to diseases and defects from which they need to be protected by gentleness and the maintenance of good general health. More will be said of these hereafter (p. 404).

The foregoing rules of treatment are all applicable for the reunion of excised parts.

For healing by granulation, if it be designed from the first, as it should be for such incised wounds as are enumerated in p. 393, the general rules about arrest of bleeding and cleansing are to be observed. If secondary hemorrhage be likely to occur, the wound had better be left open to cool air, unless it be a very large one, or on the wall of the chest or the abdomen, or over a large joint. When its surface is dry, it may be covered with dry lint, or sponge, or lint soaked in some disinfectant. If the edges of the wound through the skin come so near together that they would be likely to unite, or to prevent the escape of fluid from the deeper parts, they should be kept asunder with dry or oiled lint, passed between them to the deeper part of the wound, but leaving space for efflux. If the wound be wide open and excavated, and with uneven boundaries, it is good to fill it with dry lint, charpie, or the like substance, which may absorb its first exudations. Over any of these dressings lint soaked in oil or in a disinfecting fluid may be placed in a smooth layer; or wet lint covered with oiled silk or other light waterproof material: and if the wound be of such a shape that "bagging" is likely to take place with the flowing of pus into its lower part, this part should be supported with pads and bandage or plaster, or should have an opening for discharge.

It is generally desirable that whatever dressing has been placed in contact with a wound intended for granulation should be left till, with the beginning of suppuration, it can be removed without violence or bleeding. This may be easily and safely done if the wound be not very large, and do not involve many different tissues; but in either of these cases the discharges from some parts of the wound are likely to be decomposing, while to other parts, not yet suppurating, the dressings are still adherent. To remedy this (but the interference should not be without evident occasion), it is advisable to accelerate the separation of the adherent parts of the dressings with heat and moisture, as with poultices, or ample water dressing, or streams of warm water.

When the surface of the wound is granulating, and of course also suppurating, the essential things in local treatment are, to insure its cleanliness and freedom from all rough contact, and from accumulations of pus. These may generally be attained by daily washing with small streams of warm water from a sponge or syringe. The granulations should not be touched with anything solid, neither should they be dried or scrupulously cleaned from all their pus, unless it be decomposing. After the cleaning, the dressings should be at once replaced, and the best are lint oiled or with simple cerate, or wet lint, or wet cotton-wool, placed, in one or more pieces, smoothly and uniformly in contact with all the parts of the granulating surface, and covered with oiled silk, gutta-percha tissue, or some similar substance. As a rule, granulating wounds should be thus dressed daily, and as regularly watched to prevent or remedy, by pads or other means, the accumulation of pus.

The same methods of treatment may be adopted whether the healing by granulation be desired from the first, or whether it be resorted to after the failure of an immediate or adhesive union. In either case the process of granulation is liable to hindrances and defects of various kinds; but these, as well as the disorders of scars, which are most frequent in those formed from granulations, will be considered among the "defects and diseases of the healing process," at the close of this essay.

In the treatment for healing by secondary adhesion, the single object to be fulfilled is to bring two granulating surfaces into close, not tight, contact, and keep them so. In some cases (as after the first failure of a hare-lip operation), this may be done with sutures; but where these are not applicable, as with large granulating flaps after amputation, pads and bandages may be used. Indeed, nearly all the rules for the treatment for obtaining a primary adhesion may be followed for a secondary one.

To obtain healing under a scab, if the wound be recent, the blood and exuded fluids, or, if it be granulating, the pus, should be left exposed to the air till it dries on the wound, adhering to the edges and surface, and completely excluding them from air. Nothing more need be done, unless that the scab thus formed should be lightly covered with dry cotton-wool to protect both it and the subjacent surface from whatever may excite inflammation. For it seems to be the proneness to this morbid process which makes the healing under a scab precarious and less generally attainable than one could wish it. No morbid exudation should take place under a scab once formed; everything of the kind painfully compresses the wound and retards its healing.

In general, the healing under a scab may be allowed to take place spontaneously. But it may be favored by methods either of so-called incubation, by keeping the wounded part in heated air, or of ventilation by frequent blowing of it with fans or bellows.

The scar formed under a scab is commonly firmer and healthier than any other. Yet it may need that which all scars, even the healthiest, do—namely, such a covering as will keep it from violence, sudden changes of temperature, and excessive moisture. Cotton-wool, wadding, soft leather, or silk, will best fulfil these purposes.

Respecting the general treatment of patients with incised wounds, few words may here suffice; since, unless they become the subjects of erysipelas, or some of those diseases to which it is a peculiarity of their state that they are especially liable (which diseases are described elsewhere), the treatment may be of the very simplest kind.

Preparatory treatment.—When wounds are to be intentionally made, as in surgical operations, the rules as to preparatory treatment may be summed up in the principle that a patient is in the best state for receiving a wound when he is most nearly in perfect health. All surgeons seem to concur in the opinion that it is not wise to reduce a patient's health by bleeding, purging, or other such means, in the belief that he is thus well prepared for an operation. If a patient be in good general health, no other preparation is necessary than a day's rest: if he be ill, that which is wrong should, if possible, be set right; if have been ill-fed, he should be, for a time, fed-up; if he have been intemperate, he should be reduced nearer to moderation.[1]

Treatment of reaction.—The shock and collapse which may follow wounds are considered elsewhere. The reaction and fever which commonly next occur very rarely need treatment. Their natural tendency is to subside into health; and while, on the one hand, there is no advantage in increasing them by unusual stimulants, there is, on the other, no need to try to decrease them by purgative or other medicines. The patient during the state of reaction or of traumatic fever will generally be averse from solid food, and should not take it. Yet he should be well fed, on a mixed diet of easily digestible food; and if he have been accustomed to stimulants, their quantity should not be materially reduced, unless the signs of reaction or of fever are strongly marked. At the subsidence of the fever-symptoms, there appears to be a period in which erysipelas and other of the worse consequences of wounds are especially apt to set in. This period, therefore, may need close watching, with the design of increasing the quantity of stimulus and of food, if there appear indications of failing power, in a diminished force of the pulse, or in restlessness, or in defective heat. If no such indications are observed, the patient may gradually return to his ordinary manner of living, cleared of whatever was imprudent in it, and modified according to the different habits to which his wound may compel him. At any time after a wound, opium may be given in any quantity necessary for sleep; plastic operations on the perineum, after which it is often advisable to keep the bowels constipated for ten or more days with opium, show that, even in this constant and large use, it does not interfere with healing, or with any of the ordinary favorable sequences of wounds. And the same cases, as well as many others, will show that the quietude of the bowels, which so generally exists for three or four days after an operation, or any large wound, need not be disturbed with medicine. Unless there be some evident discomfort from constipation, a wounded patient is best without aperients: the bowels will act spontaneously in due time.

Treatment in convalescence.— Through the period of convalescence after wounds, patients that have been healthy will commonly need no medical treatment. If they can move about in the air, they may be on full diet, or on such diet as they have been accustomed to; but, if they be confined in bed, or even in the house, they are apt to be over-fed, and should be supplied more sparingly. Especially this is true of such as have required large quantities of stimulants in any of the complications of the wound or of its consequences. Such stimulants as may have helped to cure

[1] See the essay on The Treatment of Operations.

these complications will only hinder convalescence and the healing of the wound.

The period of convalescence is one in which erysipelas and such mischiefs become daily less probable ; but scurvy, gangrene, and the consequences of syphilis, struma, and other constitutional affections in those who are liable to them, may appear in any part of it. The wound must therefore be watched for these, if there be any reason to expect them, and appropriate treatment be promptly resorted to. In like manner, the defective powers of old age are more often manifested in the later than in the earlier periods of the healing of wounds. In the old, the healing process flags in its last stages, and is apt to need for its completion ample stimulants, both general and local. In the very old, the last remnant of the vital force is, as one may say, sometimes exhausted in the repair of a large wound.

Having thus included in the pathology of simple incised wounds the greater part of that of wounds in general, it may suffice if the account of the other varieties of wounds include only such things as are, severally, peculiar to them.

Punctured wounds vary in their importance according, not only to their depth and the structures penetrated, but to the instruments inflicting them. If made with small, sharp-pointed instruments, such as needles and trocars, they are rarely serious, and usually heal by immediate or adhesive union, unless they involve blood-vessels, or are inflicted on unhealthy persons or diseased structures. In these latter cases, they are peculiarly apt to be followed by inflammations of low type. They are more serious if made with larger sharp-pointed instruments, as bayonets, daggers, and the like ; and yet more so if made with blunt-pointed instruments, such as nails, forks, teeth, etc.; for by these the injured parts are not so divided as that they may retract, but are pressed aside, with much bruising, and can close again as soon as the instrument is withdrawn. Herein lie the chief peculiarity and danger of punctured wounds ; because whether blood or other fluid be extravasated into them, they do not afford sufficient facility for escape. The retained fluids decomposing, or by their mere pressure, irritate the adjacent structures, and are increased by the products of active inflammation. Hence may ensue deep and confined suppuration, and extensive separation of the tissues : mischiefs which are more especially apt to occur when the punctured wound extends through tough fasciæ, such as the palmar or the plantar, or through muscles into looser subjacent structures.

The contrast between these worst punctured wounds and the subcutaneous wounds which are made in surgery, and which are so rarely followed by any serious consequences, indicates that the chief source of the evils of the former is in the bruising and tearing of the injured parts rather than in the peculiar shape of the wound. But the treatment of punctured wounds may be copied from that of the subcutaneous. A pad should be placed on the outer wound, the deeper portion should be moderately and uniformly compressed, and the part should be kept at rest. If no pain or swelling should ensue, the dressings may be left till the healing is complete ; but in case of pain ensuing after that first caused by the wound had ceased, they should be removed. This pain will, probably, be found due to inflammation of the deeper part of the wound ; and the probability is the greater, the greater the time that has elapsed since the wound, and the more of œdema or general swelling that is present.

In cases of inflammation thus ensuing, the wounded part should be kept warm and moist. The orifice, if it be closed, may be reopened, or, in some cases, widened, to permit the escape of fluids. If no important part be wounded, it is seldom necessary or useful to apply cold, or to take blood by leeches or otherwise, or in any way to reduce the patient's strength. The pain may, for a time, be alleviated by these means, and for this purpose they may be employed in strong people. But these accidents of punctured wounds are especially apt to occur in those who are enfeebled, and in whom the better treatment is to give bark and stimulants, with local heat and moisture. In any case, when suppuration has ensued, if the original puncture be not sufficient for the exit of pus, it must be enlarged, or other openings must be made in suitable places.

Some of the worst forms of punctured wounds are those produced by sharp teeth, probably because of the force with which, as the teeth tend to meet, they crush the intervening parts. Of these it is best not to attempt the union ; they should be treated as contused wounds of the worse kind.

Contused wounds are those which, being usually produced by blunt instruments quickly moved, are attended with evident bruising in the wounded parts. (Gunshot wounds, which are of this class, are described elsewhere.) They are generally rough-edged and irregular (the less so the more swiftly the instrument has moved), and commonly they gape less and bleed less than incised wounds of the same extent. Very commonly, also, they are

attended with separation of the parts, especially of the subcutaneous tissues, both near and far from them.

In the treatment of contused wounds, it is always a first question whether it be advisable to attempt their healing by immediate or adhesive union. No general rule can be given, for the decision must depend on conditions peculiar to each case; yet it may be said that, when union is attempted, cases very often turn out much better than appeared likely, and that the failure of the attempt so seldom does harm, that it had better be made unless it is quite evidently hopeless.

For the union of contused wounds, the same rules may be followed as for the incised; but they especially need careful cleaning, removal of clots, and soft warm covering. There is no good objection to the employment of sutures, when the shape and extent of the wound do not render them unsuitable; and the general plan of dressing may be the same as for incised wounds, but with more watching for the supervention of deep inflammation or of sloughing. The former may be treated as when it occurs after punctured wounds; the latter may almost always be regarded as due not to mere severity of inflammation, but to the violence of the injury, or the defective power of the patient, or to both combined. These are, indeed, so usually the causes of sloughing after contused wounds that it is very rarely, if ever, advisable to reduce the circulation of a part thus injured, with either cold or abstraction of blood.

When the union of a contused wound is not to be attempted, the part should be kept at rest, and, as nearly as possible, at its natural temperature. For the latter purpose and for protection an excellent dressing is lint, or cotton-wool, thoroughly soaked in olive oil, and completely fitted to the part. Dry cotton-wool may be applied over this, or oiled silk. Water-dressing may be similarly applied, or warm poultices; but they are generally less comfortable, and have the disadvantage of needing more frequent change. Irrigation is, in some cases, very soothing, especially in ragged wounds of the extremities, but it should be with tepid water.

The methods of the dressing, after the first, may be in nearly every respect the same as for incised wounds.

In the case of contused wounds about the face or other parts in which it is highly desirable to avoid large scars, it is sometimes proper to cut off rough or uneven edges, or such as are likely to slough, and sometimes to dissect up flaps of skin, so as to bring together clean cut edges which may be very closely united. But the practice had better be regarded as only exceptional, for the parts in which small scars are desirable are just those that rarely slough extensively even when much contused.

Lacerated wounds, made by rending or tearing, rather than by cutting or breaking, of parts, are usually distinguished by irregularity, little or no bleeding, and comparatively little pain. The first character is probably to be assigned to the different elasticities of the structures torn through, permitting some to be much more stretched than others before they give way; and the second to the blood-vessels being pulled out before they are torn across, so that they are enabled freely and fully to contract and close their canals.

What has been said of the treatment of contused wounds might be repeated for the lacerated. The chances of union are not less; the most frequent causes of its failure are the same, and similarly to be guarded against.

Poisoned wounds owe their peculiarities so entirely to the substance by the insertion of which they are complicated, that they will be best considered with the general pathology of Animal Poisons.

Subcutaneous wounds deserve study as a class distinct from all others, not only because of their special value in surgery, but because their consequences are, in many respects, different from those of open wounds on the same parts. They are exemplified in the wounds of tenotomy, and other subcutaneous operations, in which, through small punctures of the skin, some deeply-seated parts are more largely divided. Such divisions may be made by simple cuts; but, like the open wounds, the subcutaneous may also be contused or lacerated, as in those accidents in which, through a small external opening, a tendon is pulled out of its muscle.

The immediate effects of a subcutaneous wound, the separation of its sides, the bleeding and the pain, are less than those of an open wound of the same parts; but the greater difference is in their several consequences. Subcutaneous wounds, even of great extent, commonly heal with scarcely any signs of inflammation, and without suppuration or traumatic fever; and in only very rare cases are followed by erysipelas or any of the graver dangers which open wounds may induce.

The characters of subcutaneous wounds, and their modes of healing, have scarcely been studied in any parts except the tendons; but, probably, both the one and the other are so essentially similar in all the soft parts, that what is seen in the case of divided tendons may be believed, with certain modifications, of all other subcutaneous wounds. The portions of a

divided tendon are drawn asunder by the contraction of the muscle attached to one or both, and a gap is left to be filled by reparative substance. Other tissues subcutaneously divided retract but little, and some, such as the subcutaneous fat and connective tissue, and ligaments, probably scarcely separate at all, unless they are forcibly stretched. If no notable vessel be wounded, the blood shed is usually only such as in an ecchymosis may be infiltrated in the parts near the wound. If there be much retraction of the divided structures, air often enters the small external wound; but it is probably soon absorbed, and never appears to affect the healing.

This *healing of subcutaneous wounds* may be by immediate, or by mediate, union. If the parts after division do not retract, or are placed and kept in contact, they simply reunite. The process is the same as that for the immediate union of open wounds; one description may suffice for both. But when the parts are drawn asunder, by their own or other forces, the space between them is filled with reparative material which is gradually organized into continuity, and more or less of likeness, with them.

In the instance of subcutaneously divided tendons, the first apparent consequence, after the separation of the two portions, is the production of a fluid or semifluid substance resembling, in all respects, inflammatory lymph, the product, probably, of an inflammatory process directly excited by the injury. It fills, together with small quantities of blood, whatever space remains between the disparted ends of the tendon, and is infiltrated in the tissues around and collapsed between them. The bloodvessels at and near the seat of injury enlarge; and all its appearance, for the first day or two, indicates a state of inflammation.

But this state, in ordinary well-doing cases, does not continue more than one or two days; and the inflammatory product takes little or no part in the healing of the injury; its cells are generally not developed beyond the caudate form, but rather degenerate and waste.

Two or more days after the division of the tendon (and probably a similar period would elapse after that of any other structures that retract), the reparative material is deposited in the space between the retracted portions, and in the tissue immediately investing them, and in that between their fasciculi. Similarly, it may be believed, such a material is deposited within and near and between any other subcutaneously divided and retracted soft structures; infiltrating them and the immediately adjacent tissues, and mingled with the inflammatory product of the earlier period after the injury.

The reparative material, which thus takes a similar office, in the healing of subcutaneous wounds with separation of parts, to that which the material for granulations takes in similar open wounds, is not similarly developed. At first it appears as a soft, moist, grayish substance, with a slight ruddy tinge, which, in the microscope, looks finely molecular, or dimly shaded, like homogeneous or dotted fibrine. But, as the healing makes progress, this reparative material becomes firmer, tougher, and grayer, and more defined from the surrounding parts; till (keeping still to the example of the divided tendon) it forms a distinct cord-like vascular bond of connection between the ends of the tendon, extending through all the space from which they are retracted, and for a short distance ensheathing them. Commensurately with its increasing strength and distinctness, the reparative material acquires more developed structures. Elongated oval nucleiform bodies appear in it, irregularly but densely placed; the intermediate substance, or blastema, acquires more and more a filamentous appearance, and then a filamentous structure; and as it perfects in itself the latter change, the nucleiform bodies become elongated and attenuated, and irregular as if with slight branching.

While these changes are taking place in the reparative material, the tissues about it recover from the first effects of the injury. Their bloodvessels regain their normal size, the inflammatory product is cleared away, and the several structures regain their natural mobility. Finally, the new-formed substance acquires not only the shape of the pieces of tendon which it combines, but a strength as great, and a structure nearly as perfect, as theirs.[1]

As already stated, the mediate healing of subcutaneous wounds of soft parts other than tendons may be assumed, but is not known, to be effected in the same manner. It is, however, certain that after all subcutaneous wounds, the healing, if it be not disturbed by some accident or disease, is achieved without the help of any inflammatory process, and that the materials of repair are not usually developed through cell-structures like those of granulations.

The treatment of subcutaneous wounds may be of the simplest kind, except in so far as it may need to be modified for or-

[1] The above description of the repair of divided tendons is taken from my observation of the process in rabbits. Mr. W. Adams has proved, by a valuable series of cases, that the process is in nearly every particular the same in man. On the Reparative Process in Human Tendons, 1860.

thopædic purposes. Irrespective of these, the only principles of treatment are, to give the wounded parts such a position as may be comfortably maintained and permit the least retraction; to close the external opening with a small pad or other simple application; and with a bandage, or any simple means, to keep the parts for a few days at rest. Thus treated, subcutaneous wounds will seldom fail to show the contrast between themselves and open wounds in the quietude and completeness of their healing; a contrast which appears to depend entirely on the one being exposed to the atmospheric air, and the other excluded from it.

Complications of wounds.—Passing now from the consideration of particular kinds of wounds, those complications must be described, to which any of them, or of their ordinary consequences, is liable. Of these, some are local, others general or constitutional: among the former the chief are, bleeding, *i. e.*, more than ordinary bleeding, excessive pain, morbid muscular movements, and the presence of foreign bodies; among the latter, defect or excess of reaction, traumatic delirium, fever, erysipelas, pyæmia, etc.

Bleeding, or *hemorrhage*, as a complication of wounds, may be in excess either at and continuously after the infliction of the injury, or, after ceasing, it may be at any time renewed. In the former case, it is usually spoken of as primary, or immediate, hemorrhage; in the latter, as secondary. But among secondary hemorrhages, it is advisable to distinguish those which occur within a day (or, in a few cases, two days) after the wound, from those which occur later. The former should be called "recurring;" the latter may be especially called "secondary."

Nearly the whole of the surgery of hemorrhages in connection with wounds is included in other essays (see HEMORRHAGE, and INJURIES OF ARTERIES AND VEINS). Here, only the most general facts connected with it will be stated.

The phenomena of primary hemorrhage are already described (p. 388).

Recurring hemorrhage is most likely to happen when the patient, recovering from faintness or the shock of an injury, regains that force of the circulation, of which the decrease had favored the cessation of the primary bleeding. It appears to be more frequent during the process of reaction than when reaction is completely established. It may be due to the slipping of an ill-applied ligature; but is more commonly to be referred to the relaxation of contracted vessels, or the removal of clots which were sufficient to close vessels when the circulation was feeble, or to the too early use of stimulants after wounds. And there are certain wounds in which recurring hemorrhage is peculiarly apt to happen; those, namely, which are deep and narrow, and whose sides are ill-supported (*e. g.*, wounds of lithotomy and those through the mammary gland), and those in which vessels in and near fibrous and bony structures are divided (*e. g.*, in amputation at joints); those also in the penis, the tongue, and the groin.

What has been said may indicate the cases in which more than usual precautions against recurring hemorrhage should be taken. If there be much reason to expect it, even though all care may have been taken to close every open vessel, the wound should not be closed till the patient's circulation has in some measure recovered, unless, indeed, it can be so put up as to be in every part well supported or compressed. If not closed, the wound had better be left free to the air; if closed, it should be kept cold or cool, and only allowed to regain its heat slowly. In any case, if the hemorrhage would be quickly dangerous, the wound should be watched constantly. If it be so closed that the blood cannot escape from it, the best signs of recurring hemorrhage will be swelling of the parts about the wound, considerable and increasing pain, and, if the bloodshed be large, increasing feebleness of pulse, pallor, restlessness, coldness and dampness of the skin, of which the patient himself is not usually conscious. Symptoms such as these are more characteristic of a recurring hemorrhage needing interference than is a single small or moderate escape of blood from a wound: for this commonly happens after amputations, as if in the swelling of the parts about the wound the blood that collected in it during and shortly after the dressing were emptied out.

For the *treatment of recurring hemorrhage*, if it be to a small extent, it may suffice to put the wounded part in an elevated posture, and apply cold, with ice or cold irrigation, over the wound, and compress the supplying artery. These may avert the necessity of opening the wound, if it have been closed; and are very likely to do so if, as often happens, the bleeding be from some re-opened cutaneous vessel. But if they fail, and the bleeding be deep, the wound should be opened, and cleared of all its clot; for, even though the bleeding be not profuse, it will spoil the healing process. As soon as the wound is opened, the bleeding is not unlikely to cease. If it does so, and no bleeding vessels can be seen, the wound should be left open to granulate, or at least till it become glazed, when, if reaction be complete and the speedy union of the wound be very desirable, it may be again closed. If, when the clots are removed, bleeding vessels large enough for ligature or other

means of closure, are seen, they must be secured; and the wound may be closed again. If the bleeding be from many vessels too small for ligatures, the wound should be left open to the air; or if the air have not free access, it should according to its shape be filled or plugged with dry lint made to press firmly on its bleeding surfaces. In some cases (but they admit of no general description) hæmostatics are necessary, of which the best are alum, the perchloride of iron, and the actual cautery.

The danger of recurring hemorrhage is generally past when reaction is completely established; but when such a hemorrhage has much reduced the force of a patient's circulation, there is danger of its again recurring when reaction is again in progress. The same precautions, therefore, are necessary against the repetition, as against the first event, of a recurring hemorrhage; and some of the same measures must be adopted for its remedy.

The later hemorrhages, for which the name of secondary hemorrhage should be reserved, are with very few exceptions due to morbid processes in the large vessels involved in the wound or its consequences. A ligature may be accidentally separated too early; or with overfeeding, the small vessels of the wound or its granulations may be over-filled and give way with considerable bleeding; or bleeding may occur through scurvy or the hemorrhagic diathesis; but with these exceptions, the secondary hemorrhages from wounds may be always referred to sloughing or ulceration of the walls of arteries, or, much more rarely, of veins. So long as a wound is in good progress of healing, in whatever stage, secondary hemorrhage is a most improbable event; its probability is the greater in the same proportion as the wound and the immediately adjacent parts are prone to sloughing, or to ulceration which may involve the bloodvessels, or to morbid infiltration and consolidation of the tissues. In short, the bloodvessels are ready to partake in any of the morbid processes which may occur at a wound, and through many of these are in danger of giving issue to the blood.

Thus all that relates to secondary hemorrhage as a complication of wounds will be more naturally considered with the diseases and injuries of arteries and veins and in the general pathology of hemorrhage, to which separate essays are devoted.

Pain, as a complication of wounds, varies greatly in both kind and import. In some instances it appears only as an exaggeration of the ordinary pain of wounds, severe and abiding long, through personal sensibility and so-called nervousness. This, which is usually continuous with the immediate pain of the wound, or commences not more than an hour or two after it, may be remedied by full doses of opium. In some cases, a wound is a beginning of long-continuing neuralgia in or near the injured part; and such cases commonly resist all treatment, even that which, considering their local cause, might be thought a sure remedy, namely, division of the nerve supplying the part. In some, again, a long-abiding pain seems due to partial division of a nerve, and may be cured by enlarging the wound sufficiently to complete the division. The same proceeding suffices for another occasional source of unusual pain after wounds, namely, the confinement of swelling parts under dense fasciæ. Of course if wounds become intensely inflamed, or if sloughing or deep suppuration take place, or if foreign bodies irritate them, they are generally morbidly painful; so they are when bandages are ill-applied, or sutures are too tight, or the injured part is put in a wrong posture. But the pathology of these cases is clear, and they are enumerated only because, when pain ensues as a complication of a wound, it is well to have in mind all the conditions on which it may depend, especially those last enumerated, which, in the case of recent wounds, are the simplest and most frequent causes of excessive pain. (On painful scars, see p. 404.)

Spasmodic muscular movements are not frequent complications of any wounds, except those of amputations. In these cases, "jumpings" of the limb or stump are often among the most distressing symptoms. Similar movements often occur after resections; but generally the stillness of muscles involved in wounds is more remarkable than their morbid activity. (Tetanus is not considered here; a separate essay treats of it.)

These spasmodic movements, like those which occur in severe diseases of joints, especially of the hip and knee, are most frequent during sleep. Commonly, as the patient falls asleep, and the influence of the will on the muscles ceases, he is awakened with a painful start of the stump or other wounded part; and the pain remains till the muscles are again at rest. Or, at any time, uncontrollable quiverings or tremblings of the muscles ensue, and soon lead to painful spasms of them.

Different patients suffer very variously from these spasms; but few escape them after amputations. The remedy may usually be found in careful posture and rest for the wounded part. As the similar spasms attending diseased joints are usually cured by perfect rest in splints, so are those of stumps and of resected limbs. Whatever means, whether splints or others, may be best suited for each case,

must therefore be employed; and they may be assisted with opium.

Foreign bodies may variously complicate wounds, according to their material, size, and other properties. In general, metallic bodies and others that are hardest, least porous, and least ready to decompose, do the least harm. The instances are numerous in which pieces of these substances have remained embedded in the tissues for many years after wounds, whose healing they seem not to have hindered. The probability of a foreign body thus remaining is the greater, the less the wound that it has made is exposed to the external air, and the less the suppuration which it excites. Organic substances, on the other hand, and those that are porous and easily decomposed, rarely fail to hinder the healing of wounds in which they lie, or to give rise to later troubles if wounds have healed over them.

The consequences of a foreign body being lodged in a wound are generally not evident in the early stages of healing, unless it be in contact with some very sensitive or irritable structure, the excitement of which may attract attention. The effects of a piece of metal in the cornea, or of a shot within the eyeball, are painfully evident; but they have no parallel in the immediate effects of foreign bodies in less sensitive parts. Over these, it is common for wounds to heal completely, or, failing this, to remain only as sinuses constantly discharging, or frequently closing and re opening.

If a wound have healed, the pressure of a shut-in foreign body may be suspected when there is abiding pain, or tenderness, at some one spot, with occasional attacks of inflammation in or near it; and still more when a circumscribed hardness is felt at the spot, and the patient feels such pricking or cutting as the movements of the foreign body might produce.[1] On such suspicion it is often proper to cut into the suspected place and remove whatever irritates it: but whoever does so in many cases will be disappointed in some; for all these signs of the presence of a foreign body may be exactly imitated by a painful induration of some deep portion of a scar. The chances of such disappointment will suggest caution in cutting for foreign bodies, even when patients are confident of their presence; but the risk must be often incurred, and it may be so the more readily, because the cutting will not unfrequently cure the painfulness of the deceptive induration.

If a foreign body, thus inclosed by a healed wound, be left in its place, it may become closely surrounded by healthy or indurated tissue, and cease to give trouble. This is most likely to happen if it be a metallic body; especially if it be of iron or silver, and not very sharp. If it be very sharp (as a needle), it may "travel," being moved by the pressure of the parts adjacent to it, or by its own weight. It may thus traverse considerable distances and important parts without damage; but the cases are not few in which such foreign bodies, penetrating joints, or bloodvessels, or other considerable structures, have caused serious mischiefs even very long after they first entered the body. All the cases corroborate the general principle of practice, that a foreign body should not be left, even under a healed wound, unless it is nearly certain that the operation for its removal will do more harm than is likely at any time to result from leaving it.

The repeated inflammation to which inclosed foreign bodies, especially those of organic structure, often give rise, usually indicate or lead to suppuration, and the discharge of the foreign body with the pus. This termination should be encouraged. As soon as pus is evident, it should be let out; any assistance should be given which may be necessary for the removal of the irritating substance; and what remains should be treated as an ordinary abscess.

If the wound do not heal over a foreign body, there seldom remains more than a sinus leading to the place of lodgment. Such a sinus (unless it lead into a mucous canal or a large cavity) is almost characteristic of this complication of a wound; and not the less so if it frequently closes at the surface, and then re-opens with increased discharge. Of course, the other signs of the presence of a foreign body may exist together with the sinus; and it may be within reach of a probe.

The removal of a foreign body, in the quickest and most convenient manner, is the one remedy for these cases. Slowly, or at once by cutting, the sinus must be widened, till the foreign body can be reached and extracted; or if, as sometimes happens, it cannot be found, and the sinus leads to an irregular track or deep cavity, this should be freely exposed, and filled with lint or some such substance, and healed from the bottom. If a foreign body be present, it is almost sure to appear before this healing is complete.[1]

[1] On the magnetic indications of the presence of iron bodies in the tissues, see a paper by Dr. Bence Jones, in the Proceedings of the Med.-Chir. Soc., vol. i., p. 71.

[1] The general or constitutional complications of wounds enumerated at p. 400 are treated in separate articles; see Collapse, Erysipelas, Pyæmia, etc.

The defects and diseases of the healing process and of scars remain now to be spoken of.

The healing process may be simply defective; failing entirely, or making very tardy progress. Thus, after a plastic operation, there is, sometimes, a simple failure of union (the parallel of the non-union of a fracture); or, when a wound is healing by granulation, its surface may become dry, glazy, pale, brownish, and its borders may lose their proper ruddiness and cease to contract.

It is sometimes impossible to assign the cause of these failures, just as it is with some cases of non-union of fractures. They are seen, occasionally, in very young children, *e. g.*, after hare-lip operations; more frequently they occur in old age or the simple defects of health which are most like it. During acute disease, the healing of wounds is commonly suspended or much retarded; but in chronic affections, even in chronic pyæmia, it is scarcely interrupted; and even in extreme exhaustion, as after hemorrhages or long-continued suppurations, healing may be perfect in both rate and method.

The general treatment of such merely defective healing must vary according to the general condition of the patient. The local treatment must generally be with stimulants, among which ointments or resinous substances are usually best, *e. g.*, the Peruvian balsam, or unguentum resinæ, or a mixture of the two. The part should be kept dry and warm; and if the failure of healing have occurred in a wound intended for immediate or adhesive union, the sutures (unless they are evidently doing harm) should not be removed so long as even the smallest hope of union remains. They may assist in the union by the third intention, if the earlier methods fail.

Inflammation.—In any stage of healing, *acute sthenic inflammation* may set in, with swelling and its other usual signs. But, unless it be provoked by some evident local irritation, such inflammation becomes less probable as the time from the injury increases. It is most likely to occur in the cases of wounds of those organs in which, from ordinary causes, or as if spontaneously, active inflammation is most frequent, namely, the joints, the eye, the serous membranes. The effect of such inflammation is a total suspension of the healing process, and a speedy degeneration of the reparative structures which may have been already formed. They may give way, or waste; but they should be treated as if they would recover, for they often do so.

A more frequent form of acute inflammation affecting healing wounds and the parts near them is that of a low type. It usually commences after there has been a clear interval of recovery from the first irritation of the wound; and the longer the interval, the more nearly certain it is that an inflammation will be of this type. Its effects on the healing process appear like those of the more active inflammation. Union may be destroyed, or its bond weakened by degeneration and lengthened; or granulations may become œdematous, or in some cases shrunken; and in place of pus, thin serous-looking fluid is discharged; or, new cuticle may be cast off. Commonly, the swelling that attends this form of inflammation is less than that with the sthenic type; the pain, also, is less; the redness, if any be in view, is duller and more dusky, and with a more defined border. Generally, too, the constitutional disturbance, in each case, corresponds with the type of local inflammation; in the one having the characters of acute fever, in the other those of low fever or of mere want of power.

It is of much importance to distinguish these two forms of inflammation of wounds or wounded parts, because of the different treatment which they severally require. The signs enumerated above will generally suffice; especially, the observance of the earlier or later time of the setting in of the inflammation, which is best indicated by the beginning of pain and the acceleration of pulse, and the rise of temperature. If the inflammation be active and sthenic, and perilous to the part affected or to life, active antiphlogistic treatment should be immediately adopted, and should include bleeding, either local or general, according to the condition of the patient and the importance of the seat of injury. Moist soft applications to the part are most suitable; and if the heat be great, ice, or cold irrigation, may be used with good effect. In the opposite type of inflammation, the remedies must be of an opposite kind; wine and bark are the best among them; and for local applications, warm poultices, or such as will best maintain the heat and pliancy of the affected part. Where the diagnosis of the character of the inflammation is sufficiently doubtful to justify an experimental treatment, it is best to give wine and good food, and watch their effects; for inflammations that will be benefited by these are far more numerous than those of the opposite type, and an error with these will be less mischievous than one in the opposite direction.

Another form of inflammation, not unfrequent in and about wounds that are or should be healing, is more chronic than either of these. The granulations (for it is not observable with the speedier modes of healing) become pale, firm, œdematous; and the adjacent structures feel

lumpy, heavy, firm, and consolidated, as if infiltrated with half-organized matter. Such a state occurs oftener in the healing of amputation-wounds, and excisions, than in any other cases; and, if the healing be not far advanced, may be dangerous through the usually coincident softening and degeneration of the proper textures of the part, and, among them, of the arteries. Less dangerously, it destroys the natural mobility of parts, and is associated with tardy and insecure healing.

Chronic inflammation, such as this, appears to be chiefly a local fault; at any rate, it is not generally associated with any evident constitutional error, and it usually ceases as the patient recovers power. Its effects may be remedied with stimulant applications, friction, and pressure. The ceratum hydrargyri compositum appears to be a very useful application.

Morbid states of granulations.—The analogies between a granulating wound and an ulcer are so many and close, that, as may well be expected, all the varieties of the one condition may be occasionally found in the other. Thus, as ulcers, so granulating wounds may be irritable, hæmorrhagic, painful, callous, imitating the several characters of ulcers indicated by these names. In like manner, they may at any time become affected with gangrene, or with phagedænic or sloughing ulceration. But the pathology of these states is identical with that of the cases in which they have their origin not in wounds, but in diseases or in other accidents; it is therefore referred to the essays on ULCERS and GANGRENE. Moreover, a granulating wound, especially in its advanced stages, may become the seat of a specific disease, *e. g.*, of scrofula, syphilis, scurvy, or cancer, and may assume the form of ulceration or other change characteristic of any of these diseases (see SCROFULA, etc.). Thus, through its whole course, a wounded part appears to be a structure in which morbid conditions of the blood are peculiarly prone to manifest or localize themselves. If measles or some other exanthem should make its eruption after an operation, the thickest of the eruption will be at and about the wound; similarly, the general malady of erysipelas may have its local manifestation chiefly or only at a wound; and scrofula or syphilis, which may previously have been latent, *i. e.*, without any local evidence of their existence, may find at a wound a place more fit for their manifestation than any sound or unhurt structure. When healing is complete, this aptness for specific disease in great measure ceases; for numerous as are the diseases of scars, few of them are of specific kind, and it is probable that contusions are followed much more frequently than are wounds by the growth of tumors, and these of more various kinds.

Such are the chief defects and diseases of the healing process; and, before leaving the subject, it may be well to enumerate certain causes of them, often unsuspected, but for which it is advisable to look in any case of which the origin is obscure. Some of these causes are local, namely, the presence of foreign bodies, sloughs, dead bone, collections of pus, hidden blood-clots, surrounding scars: others are general, namely, abiding chronic disease, especially of the kidneys or intestines, mental agitation or depression, bad air, especially that of hospitals long lived in, bad food, the obscure invalid state of habitual slight intemperance.

The morbid conditions of scars after wounds may be arranged as defective, painful, excessive, ulcerative, cancerous.

The *simplest defect of a scar* is that in which it remains thin, weak, vascular, moist, easily "breaking out," *i. e.*, cracking and yielding so as to expose the subjacent structures. It indicates a failure or incompleteness in the last stages of healing, a deficient development of cuticle, and too little contraction of the granulations or bond of adhesion. Such scars are most frequent after wounds healed by granulations that have become œdematous, soft, and puffy, whether through disease or through their being constricted by the contracting tissues healing round them. They are, therefore, most frequent after wounds that heal most slowly, and in weakly patients. To avoid such scars is one of the uses of cauterizing exuberant and œdematous granulations with nitrate of silver and sulphate of copper, and of dressing them with solutions of those or other astringent salts. Similar solutions are useful for the scars themselves, as also are those of bichloride of mercury in spirit; and, since scars are very apt to be cold, they should always be warmly and dryly covered. And often this care of them must be taken for many months, since not less time is requisite for perfecting, not these defective scars alone, but those which form in the most favorable manner.

Painful scars are most common after amputations, and have been often described in irritable or painful stumps. But the same affection may occur in the scar of any wound, and with the same obscurity of cause. In some stumps, it is nearly certain that the pain is due to a morbid condition of the ends of one or more of the divided nerves; not, indeed, to the formation of a bulbous swelling, for that is a general occurrence in the healing of nerves, and is commonly painless; but to the morbid adhesion of the

nerves to the end of the bone, or to the skin, so that they are kept in constant irritation or inflamed. But in many more painful stumps, no such condition can be found, and they can only be called neuralgic. So it is with other scars; and the cause of the pain is the more obscure through its commencing, in some cases, a long time (it may be years) after the healing of the wound, and without visible change in the scar.

When it is likely that the pain of a scar, in a stump or elsewhere, depends on adhesion or other such morbid condition of the nerves, the subcutaneous division lately recommended by Mr. Hancock is a very promising means of remedy. In some cases in which a particular nerve is very sensitive to the touch, though it may have no apparent morbid structure or relations, it is proper to divide or remove a portion of it. But when these measures fail, or when the case belongs to the more obscure and severe neuralgia, there remains little more than the often unsatisfactory treatments of the neuralgic affections whose cause is unknown, such as those with large doses of quinine, or of ammonia, or belladonna, or other narcotics. In the less severe cases, the local application of narcotics is commonly sufficient.

Excess of scar-formation presents various forms, if it be studied in its frequent combinations with their indurations and degeneracies. In its simplest condition it appears only as a thick or lumpy scar, which projects from the surface, instead of being plane or depressed. Such a scar sometimes follows the operation for hare-lip, and here shows its worst quality, in that it is unsightly, and apt to contract long after its formation. Similar scars, with equal inconveniences, are not rare after vertical wounds through eyelids. They cannot always be avoided; for, as the excessive formation of scars after strumous ulcers indicates, they may sometimes be due to constitutional defects; but the hope of avoiding them when their deformity would be important will justify the most scrupulous means for obtaining immediate union of the wound. When they are formed, the best method of reducing them is the repeated application of stimulants or of vesicants. *e. g.*, by painting with blistering fluid, or strong solution of iodine. The lowly organized new structures, of which the scars are composed, appear to be destroyed and made fit for absorption by the inflammation thus excited.

Scars that are thus thick have often another fault, in that they adhere too much and too long to the adjacent structures: they fall short of that stage of improvement in which there is a gradual loosening of the tissue which at first unites a scar to the parts beneath or near it. In the natural course of events, the scar which follows a deep wound through many structures is at first continuous and nearly uniform through the whole depth of the wound. If the wound have extended down to bone, and the bone be not amply covered in the healing, the scar will be depressed to the bone and so remain; but if the wound have involved soft parts alone, the scar, though it may be at first depressed, will not remain so, but will be gradually raised, by the formation of fat and connective tissue beneath it, to the level of the surrounding skin. In both cases, however, it is a part of the normal healing process, that the scar should be freed from its adhesions to the parts beneath or about it. Thus, scars that at first adhered to bone, gradually acquire freedom of sliding on it; and in those after lithotomy it becomes at last difficult to distinguish any scar tissue except in the skin.

The persistence and excess of scar-tissue existing in the failure of this loosening process is often a grave inconvenience, either by its deformity, or by rendering the scars liable to ulceration after injury or any other interference with their nutrition. It is difficult to remedy. The best means are, friction, shampooing, steaming, and, if the scar-tissue be very abundant, stimulants or vesication, as for common thick scars that are not adherent; but all must be used very gently when the scar adheres to bone.

Contraction of scars.—Another instance in which scars show excess, if not of material, yet of one of their chief properties or tendencies, is that of their morbid contraction. It is much more frequent in the scars of deep burns than in those of wounds; but may occur in any, and especially in any such as involve strong fasciæ. In some cases, the scar appears only to contract; but in more, it becomes very dense, hard, toughly fibrous, nodular, and lumpy; it usually adheres, also, very closely to the structures near it. The force of the contraction is enormous; enough to depress bone, or to displace parts from their strongest connections, or to contract them into extreme and most damaging deformities.

The almost certainty of some contraction of the scar of a wound healed by adhesion or granulation, and the possibility that it may be excessive, must be regarded in every surgical wound involving parts in which contraction would be mischievous. The length of a wound must always (if possible) be in that direction in which subsequent shortening will be least important; and it may often be right to make as careful provision against contraction of scars, as against the effect of loss of sub-

stance, by plastic operations or by lateral or other incisions. When, as in accidental wounds, no provision can be made, the healing must be carefully watched, and, if possible, some elongating force must be applied in the direction proper to counteract the contraction. Thus, for wounds near joints, if there be tendency to shortening of the scar, it must be slowly overcome by splints, with screws ; or, better, with elastic bands or cords, whose tendency to recoil after being stretched may exercise a force more powerful and not less constant than that of the scar. And the long time during which certain scars will continue to contract must not be forgotten. The length of treatment must not be determined by weeks or months ; it must be continued as long as any disposition to contract exists. Generally, the elongation may be assisted by frequent application of moist heat, or by shampooing, or other means for softening and causing partial absorption of the scar-tissues.

These same means are often sufficient for the deformities produced by the completed contraction of scars. The special mode of adapting them according to seats and degrees of deformity are described elsewhere (PLASTIC SURGERY) ; the general principles to be kept in view are, that scar-tissues can be lengthened only very slowly, and seem rather to adapt themselves by changes of nutrition to the external forces brought to bear on them than to be merely stretched ; that, in the natural course of events, in however long a time, the tendency of scars is to soften down to a greater likeness to the natural parts in both structure and relations ; that they are, as it is said, of low vital power, *i. e.*, apt to waste or ulcerate quickly under pressure, friction, or irritation, and that this quality may be often made good use of in promoting their absorption.

When this lengthening of contracted scars cannot be accomplished, the deformities due to them may often be cured by plastic operations. The chief general rules for such operations are, that if the scar is to be removed, so as to bring healthy structures together for union in its place, no portion whatever of its substance should be left ; that if the scar or part of it is to be included in any flap for sliding or transplanting, all the borders and surfaces of such flap intended for union should, if possible, be of healthy structure, and not themselves parts of the scar ; that flaps should not be dependent on scar-tissues for their supplies of blood ; and that scar-tissues alone should not be used for the formation of flaps, or relied on for any speedy or sound union.

Cheloid scars.— The most excessive growth of scars is that in which they become cheloid, a change observed most frequently in scars after burns, but not after them alone.

A scar may become cheloid, which has shown nothing abnormal in its previous course. After being completely formed, and sometimes even at a great time thereafter, it may begin to grow up, increasing somewhat in all its dimensions, but chiefly in depth, and thence becoming more and more prominent. Usually it keeps a well-defined, gradually rising, rounded border, and a smooth, level, or slightly convex, or sometimes centrally depressed, surface. Its substance is always tough and firm, and becomes more so as it grows older. At first it is usually more vascular than even recent healthy scars, and has a florid or purple tint; but, gradually, as it becomes harder, so it also becomes paler, and at length is only slightly pinkish, or scarcely more colored than the healthy skin.

All these characters of cheloid growths following wounds or other injuries indicate that they are hypertrophied or overgrown scars ; and with this agree their shape and interior structure. In shape they are like the scars that precede them, but with coarser outlines, and, if the scar were irregular, with an exaggeration of its projections, or of its extensions into the surrounding parts. On section, they present to the naked eye an appearance of closely and irregularly matted bands of white or grayish fibres, making a compact substance, lowly vascular, and thinly covered with cuticle. In the microscope, they show fibrous tissue, which, according to their date, is more or less perfectly developed, but seems always mingled with cell-structures in progress of development, or arrested and degenerate in their incomplete forms.

While cheloid growths of scars are increasing and vascular, they are usually attended with a sensation of heat and irritation ; but in their later states they are not more sensitive than common scars. After a long period of growth, they generally cease to enlarge, and rarely surpass half an inch in thickness, or by more than half an inch in any direction, the extent of the scars in which they grow. In this they differ from the fibrous growths of skin that nearly resemble them, and are of apparently spontaneous origin. They may even decrease after a long-continued growth ; and are more than common scars liable to be sore and to ulcerate.

In comparison with the frequency of wounds and scars, cheloid growths are very rare : and there is no certainty respecting the conditions in which they arise. Their occurrence in many scars in the same patient, and, much more, their repeated formation in the scars of wounds made for their removal, prove that they

depend on some personal or constitutional peculiarity; but its nature is wholly unknown.

When a cheloid growth is recent or in progress, it may be reduced and perhaps cured by active irritation, or by frequent frictions with strong ointments of the iodide or biniodide of mercury, or by frequent applications of vesicants. But against a perfected cheloid growth all such means are of little or no avail. It may be cut out, but a recurrence in the scar of the operation-wound must be feared, especially if the wound cannot be very closely healed by immediate or adhesive union. However, as recurrence is not constant, the extirpation of cheloid growths may sometimes be a proper measure; remembering only that if recurrence should ensue after excision of a cheloid, the renewed growth will be larger than that which it has succeeded, in the same proportion as the wound is larger than that for the removal for which it is made.

A singular form of cheloid growth (as it seems to be) sometimes follows the boring of the lobules of the ears for earrings. A round-oval fibrous lump forms in the lobule, greatly enlarging it, and inclosing the perforation. It may be so defined as to look like a fibrous tumor; but is usually an excessive growth of the scar-tissue, like those that may occur in the scars of sutures. The remedy is excision of the lobule; and it may need repetition.

Ulcerations of scars are not infrequent in any stage of their existence. A common form occurs in recent scars or granulations. While they are yet thin and soft, round, shallow, thin-edged ulcers form in them, exposing the lately covered surface of the granulations, as if only by the removal of the cuticle that covered them. Such ulcers are most frequent in strumous and other feeble patients, and should be treated with good food, and stimulant or astringent lotions, and with fresh air, for they often seem dependent on the confinement of a patient to a sick-room or ward. Older scars, and those of any age, may be attacked with any form of specific ulceration, but seem not peculiarly liable thereto; or, with defective health, and almost trivial injury, they may be the seats of common ulceration. Many of these cases prove the defective power of maintenance which has been already often mentioned as a character of scars. The same is shown in their readiness to slough after severer injuries and exposure to intense cold; and by the necessity of using active stimulants to procure the healing of many of the ulcers thus formed. Of all scars none are so ready to ulcerate as those that adhere to bones; and the ulceration may happen twenty or more years after their formation. The ulceration of scars is probably connected with some rapid degeneration of their tissues; but what this is is uncertain, except that sometimes a calcareous plate may be found in the scar at the bottom of the ulcer.

Tumors may grow in scars; but they are not more frequent than in many of the natural structures, unless we reckon those that are recurrent and seated in the scars of the wounds made for the removal of their predecessors. Even these, however, are usually not in, but near, the scars; and indicate the aptness of the place rather than of the tissue, where they grow.

Cancer is more frequent in scars; whether as recurrent after the removal of scirrhous cancers (*e. g.*, in the breast), or as primary epithelial cancer. The epithelial cancers, to which, under the name of warty growths on scars, attention was first drawn by Mr. Hawkins,[1] may appear shortly after the healing of the wound; but they are much more commonly found on old scars, even on those of twenty or more years' duration. Especially, they occur on such old scars as have frequently been seats of irritation or violence, and on such as are large and coarsely formed, *e. g.*, after burns, gunshot wounds, and chronic ulcers over bones.

The first indication of a scar becoming thus cancerous is, usually, its "growing up;" that is, it becomes elevated and more or less warty. The change may proceed no further, for warty scars may be found that are not, and do not become, cancerous: and enlargement of the cutaneous papillæ (the essential change of structure in warts) is very common in the scars and adjacent skin after chronic ulcers. Still, when scars become warty, and especially if they are coarsely warty, with vascular, knotted, and grouped large papillæ, bare of cuticle or very thinly covered, the probability is that they are already cancerous, and that the enlarged papillæ are filled with the cells and other structures of epithelial cancer. From this state their ordinary progress is the same as that of the papillary or warty epithelial cancers of apparently spontaneous origin (CANCER). They ulcerate at and from their centres: and as the ulceration extends, so do their borders and bases, invading the surrounding skin and the subjacent textures, as deeply as they have time for. At a late period, similar cancer affects the lymphatics in relation with the primary seat of the disease; and death may ensue.

The epithelial cancer of scars is usually

[1] Med.-Chir. Trans., vol. xix., p. 19.

of slow progress, in comparison with that affecting the natural structures, the average duration of which is about four years. Especially, it is slow when, as is most frequent, it is seated on the lower extremities. The only appropriate treatment is complete extermination with caustics or the knife if the disease be in soft parts alone, or amputation far from the seat of disease if these means are likely to be insufficient, or, generally, if the cancer have invaded bone. Such thorough treatment of these cases is certainly often sufficient to prolong life.

BURNS AND SCALDS.

By T. Holmes, Esq.

Revised by Thos. G. Morton, M.D.

Burns and scalds are, beyond all comparison, the most commonly fatal injuries which occur in civil life ;[1] and the liability to this accident appears to have been largely increased of late years, by the extended use of steam machinery, the invention and universal employment of lucifer-matches, and the nature of the modern materials and fashion of female dress. They are also, of all accidents, those which involve the most agonizing pain and the most protracted suffering; and they frequently condemn the unhappy patient to a lifelong mutilation of the most repulsive and distressing kind: they are surrounded in every period of their course by dangers, against which constant precaution must be taken: they require sedulous attention to procure the healing of vast ulcerated surfaces, to prevent deformity, to support the patient's strength, to obviate or cure visceral mischief: and they often offer most gratifying rewards to skill and patience, even in cases where ulceration has been pronounced incurable, or deformity condemned as irremediable. For all these reasons they deserve a more attentive consideration than they usually receive from either students or practitioners of surgery.

These injuries have been variously classified into four divisions by Heister and Callisen,[2] into six by Dupuytren ;[3] and various other divisions have been proposed, all of them indicating the depth of tissue implicated in the injury. Of these, Dupuytren's is the one which is most widely accepted, and which seems at once the most complete and the most practical. I shall therefore follow it in this essay, merely observing that, although of great utility, it does not, and is not intended to, embrace all the elements necessary for prognosis and treatment. It indicates the *depth* of the burn at its deepest parts; but another, and perhaps even more important, consideration is the *extent* of the burnt surface—a matter which necessarily eludes formal classification.

[The simplest classification of these injuries is that in which they are separated into three divisions:—

First degree: Erythema; hyperæmia; superficial skin irritation.
Second degree: Formation of vesicles; cutaneous inflammation.
Third degree: Eschars, devitalization of skin, or deeper parts, or carbonization of a member, or the entire body.]

The six classes into which the great French surgeon divided burns and scalds are: *First*, Erythema, or superficial irritation ("*phlogose*") of the skin, without formation of phlyctenæ. *Second*, Cutaneous inflammation, with separation of the epidermis, and formation of vesicles filled with serosity. *Third*, Destruction of the papillæ and part of the thickness of the skin. *Fourth*, Disorganization of the entire skin down to the subcutaneous cellular tissue. *Fifth*, The conversion into eschars of all the superficial parts, and of the muscles down to a distance more or less considerable from the bone. *Sixth*, The carbonization of the whole thickness of the burnt part. Of course, burns, which according to this classification are

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[1] Mr. Crompton quotes the following statement from the Registrar-General's report for 1845: "Whilst 3305 persons were killed in one year by every kind of mechanical injury, in the same period 3057 were lost by fire, viz., 148 by explosions, 2577 by burns, and 332 by scalds." Trans. of the Provincial Med. and Surg. Assoc., vol. xviii., p. 19.

[2] See Frank, Lehrbuch der Chirurgie, 1849, vol. i., p. 340.

[3] Leçons Orales, etc., Paris, 1839, vol. iv., p. 508.

described as of a particular degree, will often, and indeed usually, involve all the lower degrees as we proceed further from the spot at which the burn has been most intense.

The first degree is characterized by mere superficial redness, fading without any definite edge into the natural skin, and by a tingling sensation, and often intense tenderness to the touch. The injuries of this kind which surgeons have to treat (for the slighter cases are seldom brought under medical care) are often very extensive; being produced by the sudden and transient application of flame over a great part of the body, as in explosions of gas. They are then very grave accidents from the depressing influence which is exerted upon the brain and heart, although in all such cases the local injury is not formidable, since no sloughing is to be apprehended. The epidermis will remain to protect the surface of the true skin till a fresh layer is produced, when it separates, and the case is at an end.

In the second degree, the local injury has been carried a little farther, and the sudden afflux of blood to the surface of the cutis has been relieved by the transudation of the serum from its vessels, forming bullæ. Here the skin is in more danger than in the former case, since the detached epidermis is very liable to be peeled off, especially in extensive scalds, where the detachment is often very considerable, and where it is not rare to see a glove of epidermis separate from the hand or foot of a patient, just as it does from a macerated subject.

In the third and fourth degrees of burn, the true skin is involved, partially in the former, and in its whole thickness in the latter. It is a matter of importance to distinguish these two varieties from each other, in reference to the question of the probability of resulting deformity; but it must be confessed that it is not always possible at first. The surface in both is burnt dead, and is hard, tough, parchment-like, mottled with the débris of the blood which was contained in the tissues, and varying in color in different cases: this variation depending either upon differences in the agent by which the accident has been produced, or upon other causes difficult of determination. Beneath this eschar lies, in the former case, the deeper part of the cutis, not disorganized, but in the commencing stage of the inflammation which is a necessary consequence in the separation of the slough; in the latter, merely the loose subcutaneous cellular tissue, which is itself in most cases somewhat frizzled by the heat. The cellular tissue therefore generally contracts to some extent, so that the skin around the eschar is more puckered in the severer than in the less serious injury; and the eschar also in the former has a denser and more parchment-like appearance than in the latter. It is difficult to give an idea of this by description; but those who are familiar with these injuries soon acquire a tolerable idea of the depth of the eschar from its outward aspect. To these signs of difference Dupuytren adds, that the pain on pressing the burnt part is much greater when the burn does not involve the whole skin, and therefore the sensitive cutis receives the transmitted impression, than where the whole skin is destroyed, and the pressure is received by the less sensitive cellular tissue. This symptom, however, varies so much in different persons, and is so wholly delusive in children, who are the most frequent subjects of burns,[1] that it cannot often establish the diagnosis. If the true skin is involved to any extent, it is best to give a guarded answer when consulted as to the probability of deformity resulting, at least until the separation of the slough enables us to judge of the depth of the mischief. When the whole skin is destroyed it is only by the greatest care that contraction can be prevented; and when the destruction involves any large portion of it, some amount of contraction is inevitable.

The deeper burns are far less common, and the total carbonization of a member, which constitutes Dupuytren's sixth degree, is fortunately hardly ever met with, except occasionally in the fingers and toes, since in thicker parts it requires exposure to the flame for a period which almost involves the necessity of the patient having been utterly insensible, or forcibly hindered from moving his limb, as in the case quoted by Dupuytren from Roche, where a young man had his leg jammed into a vessel of molten metal, from which he could not extricate it. In these deep burns the surface is utterly insensible, charred, and brittle. The skin is sometimes shrivelled up, allowing the dried fasciæ or tendons to be seen through it; and the parts so charred may be broken away without pain to the patient. In the burns of the highest degree, any part or the whole member may be removed within the

[1] The extract from the Registrar-General's report, above given (p. 408), proceeds as follows: "Upon analyzing the 2909 deaths by burns and scalds, there were of—

Males between the ages of five and ten	275
" under the age of five	799
Total	1074
Females between the ages of five and ten	528
" under the age of five	672
Total	1200

Total males and females under ten years, 2274; leaving the small proportion of 635 for both sexes above the age of ten." (Loc. cit.)

area of the burn without the patient being conscious of it.

Etiology. — The causes of burns and scalds exercise some influence on the progress of the case, and consequently should always be taken into account in the prognosis. The most common, and unfortunately also one of the most fatal, accidents of this nature, is the prolonged application of flame to a large part of the body by the clothes catching fire. The cause furnishes a considerable proportion of deaths to the yearly returns of all our hospitals, and is very fatal in children. The sudden explosion of gases is another common injury; and, however superficial such burns may be, they should never be looked upon lightly, as the extensive interference with the functions of the skin which is thus caused is liable, as we shall presently see, to be followed by grave consequences, even in cases which do not prove immediately fatal from the shock and pain of the accident. The contact of molten and red-hot metals, and of substances at a high temperature, which also act chemically on the tissues, is a cause of very deep burns, which are sure to be followed by sloughing. In explosions, the mechanical violence done to the part has also to be taken into account; and in those of gunpowder we must remember that the unconsumed grains of the powder are projected into and stick in the skin, conjunctiva, etc., and should be removed when practicable.

The heat of the sun, "insolation," as Dupuytren[1] terms it, is asserted by him to be occasionally the cause, especially in hot countries, of severe burns, several cases of which have, he says, been put on record, in which severe inflammation ensued, followed by gangrene and death on the fourth or fifth day. No reference is given, and I am not aware on what authority these facts rest. The only instance which I ever saw of a person being so severely scorched by the sun's rays as to require medical attendance, was during the almost tropical heat of the summer of 1859 in London, when a young lad who had been exposed to the sun naked for some time while bathing, was admitted into St. George's Hospital, with the whole of the skin of the back burned in the first degree, and large bullæ raised upon the scapulæ. He, however, recovered speedily.[2]

Scalds are usually less severe accidents than burns, as the heated fluid generally remains only a short time in contact with the part; so that many of them escape sloughing. Their extent, however, often compensates, as it were, for their superficiality; and special circumstances render certain scalds even more deadly than the other varieties of these frightful injuries. I allude especially to those scalds of the larynx which are not uncommon in infants from swallowing boiling water, or inhaling steam from the spout of a kettle (see INJURIES OF THE NECK).

Very deep and formidable injuries are often produced in manufactories by persons falling into, or being scalded by, liquids denser than water, and which retain their fluidity at a point higher than that at which water boils. These dense fluids seem to adhere to the skin, and run down it, causing a sort of serpiginous sloughing ulcer, very difficult to heal on exposed surfaces, and which is liable to follow the flexures of the limbs, when it is apt to be succeeded by adhesions limiting their motion.

Another point of importance in reference to the causes of burns is, that various bodily conditions, principally connected with morbid states of the brain, often occasion the accident. Thus epilepsy, apoplexy, fainting-fits, and such-like affections, are very common causes of burns. Drunkenness, also, is a frequent occasion of this, as of every other accident, and is very liable, under the combination of prostration and pain which follows a severe burn, to give rise to delirium tremens. I am not aware that in epileptics the disease is usually, or even often, aggravated by the accident; at least, I have seen several cases in which no such effect was produced; nay, it has even been proposed to treat epilepsy by "firing;" a proposal little likely to find favor in the present day.

When, from any of the foregoing causes, such as coma, intoxication, or the fumes of charcoal, complete insensibility has been produced, it is possible that the whole body should be consumed gradually if the clothes accidentally catch fire. The sufferers from this accident are always very fat; and it is to this circumstance, and not to any fancied combination of alcohol with their tissues, that Dupuytren is inclined to ascribe the possibility of so singular an event. The skin is dried, charred, and cracked by the heat, the subcutaneous fat is in the mean while melted, and then pours out from the cracks in the skin, feeding the conflagration, and extending it in a similar manner to other parts of the body, till at length all that is left of what was so lately a human body is a few ashes, and perhaps some melted fat. This is what is called "spontaneous combustion;" an accident rare in any form, and which appears never to occur really spontaneously, but always as the consequence of a burn. The subject is most graphically treated in the Leçons

[1] Loc. cit., p. 506.

[2] See British Medical Journal, 1859, p. 579.

orales,[1] to which I would refer the reader for the arguments and details relating to a fact which is too remote from ordinary experience to possess much practical interest.

Finally, I may add that burns are sometimes produced by the action of lightning; but the burn is not usually a prominent feature in such accidents. The whole subject of accidents from lightning will be considered further on.

Prognosis.—The prognosis in burns and scalds depends in general on the age of the patient, the extent of the injury, and its depth; and the importance of these particulars may be estimated in the order in which I have stated them. Children are peculiarly liable to the numerous secondary visceral complications which will be pointed out as being frequent sequelæ of burns, and are especially ill-calculated to resist them; so that the risk of cerebral or thoracic affections in children is out of all proportion greater, even after comparatively slight injuries, than in grown people: and it need hardly be said that the opposite extreme of life is a condition in which its impending termination is liable to be hastened by any injury, however slight. Hence, in both the prognosis is unfavorable. The extent of surface involved is a very essential feature in the case. Even when the burn is only of the first or second degree, the shock of the application of fire to a large surface, and the intolerable pain which it occasions, render the prognosis doubtful; and where the substance of the cutis is involved over a large part of the body, and suppuration must take place along the whole extent of the wound, the chance of recovery is very small. The other primary considerations (by which I mean considerations which influence our judgment as to the probability of death or recovery) are the situation of the injury, and the length of time which has elapsed since its infliction. Burns and scalds of the chest are of all others the most fatal, particularly in children; those of the abdomen are often followed by peritonitis, those of the neck by laryngeal inflammation. Burns of the scalp are very liable to erysipelas and diffuse inflammation, but are not, as far as I have observed, so often followed by cerebral mischief as we should have expected.[2] When limited to the extremities or to the back, where the thick muscles serve as a protection to the subjacent viscera, these injuries are far less fatal. The lapse of time is always a favorable feature in the case, since the mortality from burns exhibits a progressive decline as we advance farther from the accident. But it must not be forgotten that the period of the separation of the slough brings with it peculiar dangers in burns of the fifth degree, from hemorrhage and the exposure of the great serous or synovial cavities.

Besides, however, the question of life and death, there is the very important consideration of the local result. Will the ulcer which is left be curable? What is the prospect of deformity from cicatrization? These questions will be more conveniently discussed in considering the treatment of each degree of burn.

Symptoms.—The first and most prominent, and perhaps also the most important symptom in a burn, is *pain*. No other of the many terrible injuries which it is the duty of surgeons to study approaches these in painfulness; and it is a merciful provision of nature which renders the prolongation of life impossible under the torture of a very extensive and deep burn. In cases somewhat milder than these the pain varies very much, both in severity and duration, in different persons and in different degrees of the injury. As a general rule, the deeper kinds of burn are not so painful as those in which a portion of the true skin has been involved, but yet the sensibility of the organ of touch has not been exhausted by the carbonization of its whole thickness. The pain, however, in almost every case is very severe, and ought, at least in adults, to be promptly met by the exhibition of an adequate dose of opium [or by hypodermic injections of morphia and atropia], before any other measure is taken. It will usually subside rapidly after this (although it seldom disappears), on the application of some of the non-conducting substances in common use as dressings, but occasionally resists all such means, and requires fresh doses of opium, sometimes often repeated. In burns confined to a limited spot no other symptoms are produced besides the pain and local injury, except some temporary quickening of the circulation from excitement; but it is not of these that I wish to speak here, so much as of those which Mr.

[1] Loc. cit., p. 513.

[2] A remarkable instance of the immunity which the brain often enjoys, even in very severe burns of the head, may be found in Dr. Hayward's Surgical Reports, Boston (U. S.), 1855, p. 264. A still more singular example of the same fact is exhibited in a preparation in the Museum of St. Bartholomew's Hospital (Series I. No. 100), the skull of a lunatic, who had put his head into the fire for the purpose of committing suicide. A third part of the skull has exfoliated, but the brain has not suffered in the least; and the man survived twelve years.

Crompton[1] calls "constitutional burns." Here the effect on the general system is shown at once by extreme prostration (especially if the pain have been intense and long-continued), pallor, and a peculiar terror, which frequently lasts some time in children. Delirium is often an immediate consequence of the accident. Rigors very frequently occur, and mark a severe form of the injury. The intolerable heat of the burnt part is soon replaced by a distressing chilliness, the consequence probably of suspended or obstructed circulation. The pulse is quick and weak, the tongue and mouth often dry, and thirst great. These latter symptoms are more severe, and great dysphagia may exist, when, as is often the case, the flame has passed into and scorched the mucous membrane of the mouth and pharynx.

In this stage of collapse the patient often dies without making any effort at rallying. Death is sometimes ushered in by convulsions or delirium; at others the functions of the great nervous centres remain unimpaired, or the congestion of the brain is manifested by drowsiness, and occasionally by vomiting.

This stage of prostration, or of congestion, as it has most appropriately been termed, lasts a variable time (two days being arbitrarily assumed as its limit, a limit which exceeds the reality in ordinary cases), and is followed by a period of reaction, in which, if at all, acute inflammation is to be apprehended. There is now often some degree of general fever, but this is by no means a constant symptom. The bowels are generally constipated at first, and this constipation in many instances soon gives place to diarrhœa. Vomiting often persists and sometimes exhausts the patient. This symptom, combined with diarrhœa and blood in the motions, is usually considered symptomatic of ulceration in the duodenum. Diarrhœa by itself is a very uncertain indication of any precise anatomical lesion; it is, however, a symptom by no means to be neglected, as it seems frequently to exhaust the strength with a rapidity more than proportioned to its apparent violence. When it is not accompanied by mechanical lesion of the gut, or acute enteritis, it is usually under the control of astringents, which should be combined with laudanum and alcoholic stimulants. When thoracic inflammation occurs, it is generally about this period: its symptoms are very frequently obscure; limited, perhaps, to slight cough and dyspnœa, even when the lungs are extensively hepatized. Sometimes, however, when the pleura is affected, especially by the irritation of a burn on the chest, the pain is very severe. The sloughs which form in the deeper burns are now separating, and the discharge from them adds to the weakness which is characteristic of all periods of these injuries, more especially, however, the first and last. Hemorrhage sometimes occurs on the separation of the sloughs when they are in the vicinity of large vessels, or even earlier, from the force of the blood breaking through the charred tissues, and may prove fatal. Thus a man was brought into St. George's Hospital several years ago who had burnt the back of his throat with a red-hot poker in performing some juggling tricks. It was on the second day after the accident that bleeding first occurred from the right internal carotid, and returned on the day following with such violence, that although the common carotid was secured and no further bleeding took place, he sank rapidly. Arterial hemorrhage is, however, very rare in burns. I find no other case noted in the Hospital Case-Book, which extends over twenty-five years, and contains the history of every patient who has been examined after death. The cause of this rarity is, doubtless, that the large arteries lie under the protection of strong fasciæ, which are very seldom burned through, except in injuries so severe as to destroy life before the time at which hemorrhage would come on.

The limits which separate the second period, that of reaction and inflammation, from the third, that of exhaustion or suppuration, are even more arbitrary than those which mark the passage from congestion to inflammation. I shall follow other writers in taking the end of the second week as the termination of the second period for statistical purposes; but it must be understood that in each individual case the third stage is reached after the sloughs have separated, and the process of suppuration has become fairly established, from the whole surface of the wound. In this third period, internal inflammations, though not so frequent as in the second, are by no means rare. They are still more decidedly of the asthenic form, and are often entirely latent, being revealed from time to time in the post-mortem examination of patients who appear to have sunk from pure exhaustion. The general symptoms are usually those of weakness merely; sometimes the bowels continue irritable for a considerable time; occasionally, in children, convulsions come on at a late period of the case when none had occurred earlier. The various complications to which these, like other wounds, are subject, may come on at any period. Tetanus, erysipelas, and diffuse inflammation are not, as far as I

[1] Loc. cit

have observed, more frequent complications of these than of other accidents: while pyæmia is decidedly rare. As the case progresses, the local phenomena gain in relative importance upon the constitutional, until at length an old burn terminates as a case merely of vicious cicatrization or obstinate ulcer. In this stage it may last an indefinite time, or remain absolutely incurable.

Burns are liable to prove suddenly fatal at all periods of their course; though this accident becomes more rare as the injury becomes more remote. The most common cause of sudden death at the commencement of the case is convulsions in children, in whom this complication is usually, if not solely observed. After the fourth or fifth day, death may be produced suddenly by an ulcer of the duodenum perforating an artery[1] or the peritoneum. Some rare cases prove fatal at various periods from causes which baffle pathological inquiry. [Uræmic poisoning in many of these cases is highly probable, for as will be shown further on, the kidneys in severe, and indeed in some of the milder injuries, early become involved, as is demonstrated by the presence of albumen in the urine, which appears almost simultaneously with reaction and high temperature.] In some of those cases ulcers of the duodenum have been found, and vomiting [uræmic?] has preceded death; but this hardly accounts for the rapidly fatal and unexpected seizure.

Pathology and Treatment.—The treatment of burns divides itself naturally into two very different parts, the local, and the constitutional. The former is best determined by experience, and by attention to the general rules of surgery; for the latter a knowledge of the remote consequences of these injuries is required, which can only be obtained by post-mortem investigation.

I shall, therefore, endeavor to set before the reader, more fully than has been done elsewhere, as far as I can discover, the pathology of these injuries, with a view to determine the viscera or functions which are more peculiarly threatened, the causes and modes of death, and hence the indications for their constitutional treatment.

The pathology of burns has been more closely studied, and the importance of the remote lesions which they produce in the viscera has been more accurately appreciated, since Dupuytren[2] called the attention of the profession to the prevalence of inflammation of the gastro-intestinal mucous membrane, and Mr. Long[1] gave precision to this observation by pointing out the ulceration of the duodenum which so frequently accompanies severe burns. The only pathological researches, however, with which I am acquainted, which are at once accurate and extensive, are those of Mr. Erichsen,[2] who has tabulated fifty fatal cases of burns and scalds in order to determine the organs most frequently affected in each degree and period. I shall make frequent reference to this valuable table, and to another similar table in my own possession, compiled from the case-books of St. George's Hospital, and containing a full account of the history and post-mortem appearances in seventy-five fatal cases.

As the method and principal cause of death is a point of the greatest importance to ascertain, in order to determine the general direction which our treatment should take, I have examined the notes of those seventy-five cases with a view, if possible, of deciding this point. Mr. Erichsen's table does not contain the symptoms during life, and is therefore not available for this purpose.

Seven cases must be deducted, in which the history does not enable us to draw any positive conclusion, or where the patient died of some other disease. Of the remaining sixty-eight, nine died of shock, all within two days; seventeen of exhaustion, accompanied in some cases by visceral lesion, but without any striking functional disturbance. Five of these cases proved fatal within a week, but the majority survived for a much longer period. Erysipelas was seldom noticed, and proved fatal in only three instances, in all of which the scalp had been burnt. Pyæmia is a rare accident in burns, as might have been anticipated from the fact that the bones are rarely injured, and that phlebitis is almost unknown. It occasioned death in three cases, one of which, however, was somewhat doubtful. Two died of tetanus. Thus thirty-four, or exactly half the cases, died of affections of a low type not depending on local mischief or visceral disease.

Passing on now to the affections of individual organs, we find that the brain was the seat of fatal mischief in eleven cases. All of these were children, and nine of them under five years of age. The death usually took place soon after the accident, but in three cases the fatal seizure did not occur till a late period. The brain was in most cases found congested and wet; in two, inflammatory softening existed.

Six cases died from inflammation of the

[1] See the illustration on page 419.
[2] Op. cit., pp. 521–525.

[1] London Medical Gazette, Feb., 1840.
[2] London Medical Gazette, Nos. 789, 790.

larynx or trachea; five of the patients were children; one a woman seventy-eight years old. They all died within two days, except one, who survived till the third. Tracheotomy was tried in two cases, and in one was thought to have prolonged life.

Twelve died from thoracic complications. In all of these the chest, or its immediate neighborhood, was injured; all, except four, were children. The periods at which the cases proved fatal were very various.

Four only died from the direct effects of abdominal lesions, and in one of them the manner of death was obscure. One was a case of peritonitis, occasioned by a deep burn on the abdomen. Two others died from sudden hemorrhage in ulcers of the duodenum. The period of death was ten and five days respectively. The fourth case was one of those obscure instances of sudden death which sometimes occur in these injuries. The patient had gone on satisfactorily for more than ten weeks, and was then seized with vomiting, which proved fatal on the same day. Nothing was found to account satisfactorily for the rapidity of the death; but, as the duodenum was found extensively ulcerated, it is classed in this category. It is most probable that the vomiting was connected with this ulceration, and death might have been induced by some affection of the great sympathetic ganglia in the neighborhood. This is a point, however, on which it is not worth while to theorize here. We are only concerned to remember that these sudden and obscure deaths are not very uncommon in burns, and have been noticed by many authors. Hence it is always prudent to be a little reserved in our prognosis.

One case remains to be accounted for; in this the patient died of hemorrhage from the internal carotid artery.

Possibly this may be more easily followed in a tabular form. Of 68 fatal cases of burn, examined after death,

34 seemed to die from general causes, viz.:—	9 of shock. 17 of exhaustion. 3 of erysipelas. 3 of pyæmia. 2 of tetanus.
34 from the effect of local lesions, viz.:—	11 of cerebral complications. 6 of laryngitis. 12 of thoracic complications. 4 of abdominal lesions. 1 of hemorrhage from the carotid artery.

The above facts show how much more common, especially in adults, is death from shock and from exhaustion than from any internal inflammation, and how nugatory antiphlogistic measures and severe regimen must be, which are directed against apprehended inflammation; measures which are at all times of doubtful utility in checking such inflammation, while they cannot fail to aggravate the tendency to exhaustion, which is so much more to be apprehended, and so much more likely to prove mortal. The actively-fatal inflammations of the peritoneum, pleura, and lung are hardly ever met with, except in lesions of the parietes which inclose them. Adults hardly ever die of any other cerebral affection after burns than delirium tremens.

Pathology of the first period.—Of the cases of burn that prove fatal, a great majority die in the *first period* of the disease, that is, in the first two days after the injury; often before there has been time for the occurrence of inflammation.

Mr. Erichsen's table contains sixteen such cases, and my own, nineteen; *i. e.*, thirty-five, out of 125 cases in which post-mortem examination was performed, had died on the first or second day of the injury; but as the great majority of those who are thus "burnt to death" are not examined, we may be sure that the true proportion is much greater than this. Thus, in the same period (sixteen years), during which the seventy-five cases above referred to occurred, 119 other fatal cases of burn were brought into St. George's Hospital, which, by order of the coroner, were not examined after death; of these seventy-nine died in the first period, twenty-six in the second, and fourteen afterwards. The cause of death in the large majority of these cases is shock; a somewhat vague term, which has been variously interpreted by different authors. Dupuytren imagined that death, in the early period of burns, is produced frequently by excess of pain,[1] and thus explained the occurrence of death by shock; but this explanation can hardly be considered as worth much, since it leaves us as much as ever in the dark as to the mode in which death is brought about. It seems more natural to attribute the fatal result to the disturbance of the internal circulation, produced by the sudden check to that through the superficial vessels.

[1] Op. cit., p. 518.

Congestion of the brain and mesencephalon, among other viscera, is thus produced, which manifests itself in a suspension of the functions of those great nervous centres.[1] This view derives all the confirmation which anatomy can give it, from the fact, that some unnatural congestion of the brain is always, or almost always, found in examining the bodies of those who die at this period. Of Mr. Erichsen's sixteen cases, "the brain and its membranes were found congested, with more or less serous effusion into the ventricles, or arachnoid, in fifteen cases." The other was not examined. I have not myself found this appearance quite so uniformly, but the results of my table are sufficient to give a general support to Mr. Erichsen's views, as in those cases where the brain was examined (unfortunately only very few), I find only one in which it is asserted to have been healthy in respect of structure and vascularity. Congestion of the other viscera are also very common, or rather, internal congestion is probably always present, although it is not always possible to recognize this condition by post-mortem examination. Thus of Mr. Erichsen's sixteen cases, thoracic congestion was noted in eight, and in six of my nineteen cases; while the congestion had passed on to demonstrable inflammation in one of the former, and in three of the latter: or, in general language, there were traces of thoracic congestion in one-half of the cases examined. Those who have observed how frequently the tissues (and more especially the mucous membranes) lose after death all traces of the congestion, which we know from infallible signs to have existed during life, will not hesitate to admit from this evidence that there is a great tendency to congestion of the thoracic viscera in every case of severe burn. Of course this tendency becomes more formidable in proportion as the burn approaches nearer to the situation of those viscera. Congestion of the abdominal organs is less frequently met with, although by no means uncommon, since twelve out of Mr. Erichsen's cases displayed this condition. Among my cases, however, it is noted in only three instances; but in one of these it had advanced to such an extent as to produce extravasation beneath the mucous membrane of the cæcum.

Another extremely common seat of congestion is in the mucous membrane which lines the pharynx and larynx. This is, no doubt, at least in the great majority of cases, the result of the inhalation of flame or heated air during the accident. Of the nineteen cases in my table which died during the first period, only six wanted some appearance of congestion in this part. The congestion in the pharynx very generally ceases abruptly at the commencement of the œsophagus; in some rare cases, however, it extends into the stomach. It frequently gives rise to inflammation and effusion in the submucous tissue about the fauces; but I do not find among my notes much reference to symptoms dependent upon this condition, except an occasional notice of dysphagia, and it is of subordinate importance.

Not so, however, the same condition in the larynx, which often coexists with the congestion of the pharynx. This is very apt to produce œdema glottidis, spasm of the glottis, and all the fearful consequences which follow such spasm. Nine out of my seventy-five cases presented traces of inflammation of the larynx, which in three of them seemed to have been the sole cause of death. In the scalds of the glottis, to which children are so liable from inhaling hot water or steam from the spout of a kettle, this condition inevitably occurs, and is very fatal. If emetics and the moderate use of antimony with or without calomel do not very shortly improve the state of the breathing, laryngotomy is the only resource; one which too often proves unavailing. The reader will find this point more fully treated under the head of Injuries of the Neck. Besides these nine cases, three died of inflammation seated lower down in the trachea.

So much for the post-mortem appearances in the first period. What indications are to be drawn from them? The existence in all the most important viscera of extreme congestion, which passes on very rapidly to inflammation,[1] may be, and has been, taken to be an indication for so-called "antiphlogistic" measures; and accordingly we hear of bleeding from the jugular vein to obviate cerebral inflammation; of leeches, to prevent abdominal complications; of bleeding from the arm, to guard against pneumonia; of mercury, tartar-emetic, and low diet. Now, without going so far as to assert that cases may not occur in which such measures may be useful in the period of inflammatory reaction, I believe that the theory which would recommend them in the first stage of the injury is an erroneous one. The congestion is due to the sudden revulsion of blood from the surface, by which the heart is oppressed, and the stagnation thus perpetuated. The congestion, in a word, is passive. To remedy this mechanically, by taking

[1] See Erichsen, loc. cit.

[1] I have notes of several cases, in which effusion of lymph was found on the day after the accident.

blood out of the veins, is, I believe, impossible; and, indeed, the state of prostration in which the patient is always found is such, that I never saw a case in which any such proposal was made. Nor is any reduction in the mass of the blood desirable, since the patient will soon be in a condition in which he will require all his strength. Diffusible stimulants afford, I believe, the means most likely to succeed in arousing the powers of the circulation, and restoring the succession of those vital changes in the great nervous centres on which the patient's chance of surviving depends. The depression, coldness of the surface, and sinking, should be combated by warmth to the surface, generous diet, and small but frequently-repeated doses of alcoholic stimulants and ammonia. These must of course be given cautiously, since sthenic inflammation of the thoracic viscera may supervene; but they may be pushed till the strength of the pulse rises to the standard of health; and as it does this, its frequency will probably be found to diminish. Opium [particularly in combination with atropia] is of great service in the period of pain, terror, and depression which follows severe burns in adults, and may be given liberally. In children, in whom the tendency to congestion of the brain is so marked, it should be used cautiously, if at all.

Pathology of the second period. — The second period is more peculiarly that of inflammation, and is usually held to commence at the end of the second day, and to extend to the end of the second week. During this period, twenty-nine out of my seventy-five cases died, and twenty-five out of Mr. Erichsen's fifty; or fifty-four cases out of 125. The visceral affections at this period are principally of the brain and lungs, and intestines, since the cases in which the larynx is injured usually die earlier. Of Mr. Erichsen's twenty-five cases, the brain was affected in fourteen; eleven being simple congestion,[1] and three serous effusion. Of my own twenty-nine, the brain was left unexamined in the great majority; and this, I conclude, was in consequence of the absence of cerebral symptoms. Three, however, are noted, in which the occurrence of convulsions or obstinate vomiting drew attention to the brain. It was found congested in all, with effusion of fluid into the ventricles, or arachnoid; but there was no evidence of true inflammation in any case.

The lungs are more frequently affected. Thus, in Mr. Erichsen's table the lungs were congested in ten cases, and inflamed in five. Out of my own twenty-nine, inflammation of the lungs or pleura had occurred in seven cases (in one, however, it was believed to have existed before the accident), and congestion is noted in five others.

The lesions of the abdominal organs are of extreme interest, on account of the singularity of the appearances which they present, and the physiological speculations to which they give rise. They are entirely confined to inflammatory phenomena in the gastro-intestinal tube. None of the other abdominal viscera (liver, spleen, or kidneys) are, as far as I have observed or can discover in authors, ever affected as a consequence of burns except in pyæmia.

[Examinations of the urine, made in a large number of cases of burns and scalds at the Pennsylvania Hospital, agree very remarkably in one feature, *i. e.*, albuminuria. They showed, at least, unmistakable congestion of the kidneys following reaction, and almost invariably when a temperature of 101½° or 102° F., or over, was reached, albumen appeared in the urine.

The amount varied according to the severity of the burn, and increased with the subsequent rise of temperature; as the latter varied, so the amount of albumen increased and diminished; when the thermometer indicated 100° or less, the albumen disappeared entirely. In several cases epithelial and hyaline casts were found. In one case of fatal general burns in a pregnant woman, whose temperature on admission was 99°, the first urine which was drawn by catheter showed a light ring of albumen, due to the pregnant condition; within forty-eight hours, the temperature rose to 105°, and the urine was heavily loaded with albumen, and its specific gravity 1006. It is interesting to note here that the patient was soon after admission delivered of a dead infant, and the remarkable fact was noticed that the child was "apparently blistered and burned in extent and places almost exactly corresponding to the injuries of the mother.]

The inflammation of the intestines rapidly passes on to ulceration of the mucous coat, and is so generally limited to the duodenum, that little attention has been paid to lesions of other portions of the intestines or of the stomach, although they do sometimes occur. The earliest period at which I find notes of ulceration of the duodenum is in one of Mr. Erichsen's cases on the fourth day. In my own table, two cases are noticed on the fifth day, and one on the sixth. The

[1] I may remark that, in the absence of notes of the symptoms during life, no great importance is to be attached to the mere record of "congestion" of the cerebral vessels after death. Hardly any post-mortem appearance is so variously estimated.

whole number of cases in which ulceration of the duodenum was discovered during the second period was, out of Mr. Erichsen's twenty-five, six; out of my twenty-nine, four; to which two ought to be added, in which, though the duodenum was intact, extensive ulceration was found in other parts of the intestine. This gives twelve cases in the second period out of fifty-four. The duodenum in three other of my cases presented enlarged glands; and in one of these the enlargement affected also the glands throughout the whole intestinal tract. Congestion is also frequently found; but its pathological importance appears slight at this period of the disease. The whole subject of abdominal lesions will be resumed further on, with the pathology of the third period. It will be sufficient for the present purpose to state that in the cases in which ulceration occurred it was unaccompanied by general inflammatory symptoms in any instance; and that where it caused death, that result was occasioned by hemorrhage.

On consideration of the symptoms which accompany these inflammations, it must be allowed that they [decidedly] contra-indicate the use of active depletion, and that the object of our treatment should be rather to support the patient's strength, and enable him to live through the local action which is probably inevitable. Care, of course, should be taken not to over-feed or over-stimulate a patient with inflammation of the lungs or bowels; but, in these as in all other cases in which inflammation follows injury, the general treatment should be guided by the general symptoms, and especially by the tongue, the pulse, and the state of the skin; and if the pulse is weak, and the surface cold, stimulants should be prescribed with generous diet if the condition of the tongue allows of it, even though the patient is known to be affected with thoracic or abdominal inflammation; while in the opposite state of the system it may be proper to pursue the antiphlogistic regimen. The surgeon must be guided in this, as in so many other matters, more by common sense, and a competent knowledge of the principles of his art, than by rule and theory. In the practice of our metropolitan hospitals, we have frequent opportunities of witnessing the success of the stimulating treatment, even in cases of acute visceral inflammation; and such treatment has now become common in the hands of many of our best physicians; while in a different air, and among people of a different constitution, the antiphlogistic plan may be indicated, and may prove successful. Experience and tact will decide the question in each case; but there can be little danger in asserting that bleeding, low diet, mercury, and tartar-emetic, are not likely to obviate ulceration in persons of weak constitution and irritable circulation; and that, as far at least as the abdominal complications are concerned, they are more under the control of stimulants combined with opium. The thoracic inflammations are still more difficult to deal with. I have notes of a case in which fatal pleurisy supervened directly after, and very probably in consequence of, free stimulation, which nevertheless was necessitated by the general condition of the patient; while, on the other hand, my notes tell of several cases in which, notwithstanding the known presence of inflammation of the thoracic viscera, it was impossible to use depletion on account of the patient's debility. Local antiphlogistic measures, combined with general stimulants, offer the best prospect of success in these difficult, and generally unsatisfactory cases. I have seen instances in which some good seemed to result from the combination of moderate doses of tartar-emetic with the stimulating regimen.

Pathology of the third period.—If we pass now to the third period—that which is called the period of suppuration or exhaustion—we shall find that the causes of death are by no means limited to the exhaustion either of profuse discharge or of protracted suffering, but that inflammation enters largely into the category. As to the proportion of deaths which occur at this period, Mr. Erichsen's table and mine are somewhat at variance, his giving only nine out of fifty, less than one-fifth, mine twenty-seven out of seventy-five, more than one-third.

The lesions of the brain which are met with at this period are not very important, and are in fact, so to speak, accidental, being limited almost entirely to cases of infantile convulsions and pyæmia. I shall therefore dismiss them as requiring no special consideration.

The chest is more frequently affected, and this affection is a very frequent cause of death. It occurs chiefly when the injury has affected the walls of the thorax. In Mr. Erichsen's table, lesions of the lungs and pleura are noted in six cases out of nine. In four the appearances were distinctly inflammatory, and in the two others there was congestion, with effusion into the pleural cavities. In my collection, out of twenty-seven cases, morbid appearances are noted in the lungs in ten; and in eight of these the inflammation, if not the sole, was at any rate a principal, cause of death. The diagnosis of the presence of thoracic inflammation is not always easy, since the burn is usually situated on the chest, and precludes the possibility of physical examination; but hacking cough, bloody

sputa, or pain in the chest, will direct attention to the lungs or pleura, and set the surgeon on his guard. The indications for treatment, however, are perplexing in the extreme, since weakness is a more prominent feature than in the second period. Indeed, all means of treatment will usually fail, and the cases must be looked upon as almost hopeless.

Lesions of the abdominal viscera are frequently met with during the third period of burns. Out of the twenty-seven cases in my table proving fatal during this period, there were six in which open ulcers were found in the duodenum, one in which a similar ulcer was found cicatrized, one in which the whole mucous membrane of the small intestines was found inflamed, but not ulcerated, and one in which the duodenal glands were found enlarged. Mr. Erichsen, however, found no instances of ulceration of the intestines among the nine cases in his table.

Intestinal ulceration is a sufficiently common phenomenon in every period of burns and scalds. Of the 125 miscellaneous fatal cases from which this account has been compiled, sixteen presented ulceration in the duodenum, five of which died during the first week (four days being the earliest period), five in the second week, and the other six after longer periods, one as late as the seventy-fifth day. The patients' ages varied as much as the period of death; four were children of the ages of 5 or 6; two young adults 19 and 27 years of age; two in the middle period of life, 37 and 42 years old; and two aged persons, 66 and 78 years of age. The situation of the burn was very various. In two cases the extremities only had been burnt; but in all the rest some part of the trunk (chest or abdomen) had suffered. The appearance is that of a perfectly indolent ulcer; it is usually seated just below the pylorus; often there are two or three close together; the edges of the ulcers are not raised nor everted; there is little or no evidence of vascular action or inflammatory effusion in their neighborhood; when they are recently formed, they look simply as if a portion of the mucous membrane had been cut out. But when the ulcer has penetrated more deeply, so as to threaten perforation of the gut, lymph may often be found effused on its peritoneal surface; a natural barrier, apparently, to the fatal progress of the disease. Sometimes the glands of the duodenum may be found enlarged; but though this appearance is sufficiently common in all cases of burn, it does not appear that it is at all a constant accompaniment of those in which ulceration exists. It has been assumed rather than proved, that the enlargement of the glands is the first step in the ulceration. It is quite possible that it may be so; and the theory, which was first broached by Mr. Curling,[1] on the suggestion of Mr. Bowman, is that the strain thrown upon the intestinal glands, especially Brünner's, in separating the watery material out of the blood which accumulates in it from the suspension of cutaneous perspiration, is the cause of the diarrhœa and ulceration. This is the only rational explanation yet offered of the pathology of this lesion; but it is purely conjectural.

[In accounting for these results of burns and scalds we may remember digestion of the stomach or intestinal wall is believed to occur from any interference with the local circulation in them. Ziemssen ascribes this pathological change to the action of the gastric juice, thinking that the primary lesion is a local arrest of circulation, and that the formation of the ulcer at this point is a secondary and necessary result of the action of the digestive juice. Hemorrhagic necrosis, according to Virchow, is the cause of these ulcerations. Ziemssen shows further that the circulation of the blood in the tissues of the intestinal wall renders them constantly alkaline, and thus protects them in health from self-digestion. Reindfleisch also refers to hemorrhage as the cause of these ulcerations, saying that each hemorrhagic infarction becomes a caput mortuum, its organic connection with the healthy mucous membrane is destroyed, and the actual separation is only a question of time; the simple ulcer, therefore, takes its departure from a hemorrhagic infarction. If the infarction has been dissolved and removed (digested) by the action of the gastric juice, there remains behind a correspondingly large loss of substance, the ulcus simplex is established. From this time out it may enlarge, it may attain the dreaded developmental climax of a perforating ulcer; upon the other hand, it may also become smaller and cicatrize.]

If we inquire into the symptoms of ulceration of the duodenum, we shall find the results principally negative. In the large number of cases which are comprised in these tables, and which have been observed by persons sufficiently competent and careful,[2] I can find no evidence that the *accession* of this ulceration is announced by any unmistakable symptoms. No pain appears to be complained of in the part, nor is it noticed that the region of the duodenum is tender to pressure. Diarrhœa is not constantly present,

[1] Med.-Chir. Trans., vol. xxv.

[2] The notes in my cases were taken by myself for five years, and by the other Hospital Registrars for the time being. In Mr. Erichsen's table the authorities are given.

nor when present is it by any means decisive of the point. Vomiting does indeed frequently occur in the early stage of ulceration of the duodenum, but it is as often symptomatic of cerebral as of intestinal or gastric irritation. We are therefore left, to a great extent, in the dark as to the early symptoms of this affection; and all that we are entitled to say upon the subject is, that the occurrence of obstinate diarrhœa and vomiting should always direct our attention to the

Fig. 69.

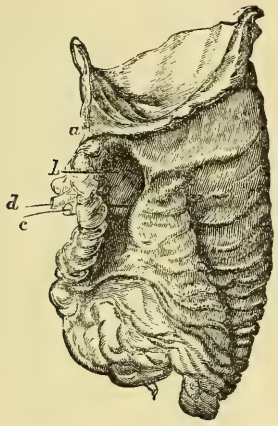
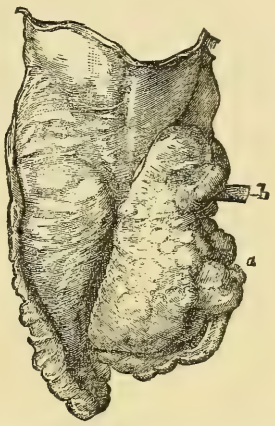


Fig. 70.



Ulceration of the duodenum in a burn, causing death by hemorrhage from a large branch of the pancreatico-duodenal artery.

Fig. 69.—Internal view.—*a*. The pylorus. *b*. The ulcer on the duodenum close below the pylorus. *c*, *d* Bristles passed through the artery and vein, which are seen to open freely on the ulcer.
Fig. 70.—The opposite view of the same preparation.—*a*. The pancreas. *b*. The artery which was ulcerated.

stomach and duodenum; that careful palpation of this region may sometimes assist our diagnosis; and that the presence of blood in the evacuations is strongly confirmatory of it. When the severe symptoms, which are occasionally noticed, come on, intense pain, copious hæmatemesis or melæna, distension of the abdomen, rapid sinking, we may be sure that the ulcer has proceeded to perforate either the peritoneal coat of the gut, or some considerable vessel (probably the pancreatico-duodenal artery), and that the case is beyond the reach of remedies. The accompanying figures are from a preparation in the Museum of St. George's Hospital (Series ix., No. 142), showing a large branch of the pancreatico-duodenal artery opened close to the parent trunk by an ulcer of this nature.

The diagnosis, then, of intestinal ulceration being so obscure, what is the prognosis? It was supposed, when this complication was first pointed out, that it was necessarily fatal; but that this supposition is erroneous is proved by the records of cases in which such ulcers have been found cicatrized. Mr. Curling gives one such case;[1] and my notes contain another. In the latter instance, the patient, a child æt. 3½, died on the twenty-eighth day after a severe burn on the chest, arms, and thighs. The proximate cause of death seems to have been pneumonia, combined with exhaustion from suppuration and diarrhœa. A circular patch, about the size of a fourpenny piece, was found at the commencement of the duodenum, where the mucous membrane was deficient, and the exposed surface cicatrized. It is interesting, as showing the uncertainty of diarrhœa as a symptom in these cases, to notice that here it occurred for the first time on the twenty-third day, when the ulcer must have been nearly, if not altogether, healed. From the facts, then, that cicatrized ulcers are sometimes found in patients who have died of other complications; that the lesion does not of itself produce any symptoms of dangerous disturbance of the health; and that it is frequently discovered in cases where it would never have been suspected, I am inclined to think that it may be present in many of the cases which recover, and that its importance in practice has been exaggerated.

Other parts of the intestines are sometimes, although rarely, affected. My table contains only one case in which the jejunum and ileum were ulcerated, the duodenum being intact. Peritonitis was not associated with it in any case. When the serous membrane is affected, it is always, as far as I can see, the result of local irritation from burn of the abdominal parietes, and affects the low purulent form, rather than the adhesive.

[1] Medico-Chir. Transactions, vol. xxv., p. 280.

Thus it will be seen that all the inflammatory phenomena connected with the lesions of the intestines belong to the class of low inflammations; that they are not ushered in by any of the local or general symptoms which accompany acute disease, and that when they prove fatal, it is by the secondary consequences of the ulceration (perforation or hemorrhage), and not from any interference with the function of the gut, nor any impression on the general health.

It may seem absurd to talk about the treatment of an affection which, generally at least, eludes diagnosis. Still, as the frequent presence of ulceration in the intestine has been made a pretext for recommending a more active antiphlogistic regimen in burns, it is right to point out that a more attentive consideration of the question would have shown that the indications are all the other way. If the insidious progress of a duodenal ulcer can be stopped by any remedies before it has opened the pancreatico-duodenal artery or perforated the peritoneum, it must assuredly be by some means different to those which may be used successfully in preventing plastic exudation or restraining vascular action. It is hardly likely that reducing the patient's already exhausted powers can have any other effect than to hasten the progress of the ulceration, and add fresh victims to that "majority" which already owes so much to the "nimia medicorum diligentia." In all stages, then, of the treatment of burns, great caution should be exercised in the use of antiphlogistics; and the only period in which they are admissible at all, unless in very exceptional circumstances (such as some instances of scald of the glottis), is during the second period, in thoracic inflammation; and even there, as has been said before, it will be generally found impossible to press the treatment.

Local treatment.—The local treatment of burns is a subject on which many books have been written, and perhaps more numerous remedies recommended than in any other branch of surgery. The success which is said to have attended very different, and even opposite, modes of treatment shows that the authors must either be misrepresenting the facts or speaking about different matters. I prefer the latter explanation, more especially as I find that authors who have written to recommend certain methods have almost invariably spoken of burns as if they were all alike, forgetful apparently that the essential question in the local treatment of a burn is its depth, or degree, and the consequent probability of sloughing, ulceration, or mere inflammation resembling that of erysipelas. It is only by keeping this point steadily in view that we can hope to arrive at any rational plan for the treatment of these injuries.

1. First degree. In cases of burns of the first degree, little local treatment is necessary, except to keep in contact with them any application which will relieve pain and exclude the air; if, at the same time, it tends gradually to constrict the vessels of the skin, dilated by the sudden stimulus, so much the better. Cold applications are usually more agreeable than warm, lotions than ointments. In hospitals, the usual application is Goulard-water on rags frequently irrigated; cold water does very nearly as well; but a host of remedies are in domestic use—scraped potatoes, ink, moist earth, etc., etc., all of which act on the same principle.

If, however, the burnt surface is very extensive, and the patient is much depressed from fright or pain, it would be injudicious to chill the surface further by cold applications; and then it will be better to wrap the part in cotton-wool, or powder it thickly with flour, or to use some of the stimulating substances which will be enumerated further on. The new epidermis is formed usually in two or three days, after which no further application is required. The vessels of the skin, however, will remain dilated for some time, as they do after a blister.

2. In the second degree, the principles and details of the treatment are very much the same as in the first, except that care must be taken to preserve the epidermis. It is often (especially in extensive scalds) raised from the skin in very large blebs filled with serum, which adhere to the clothes, particularly when the latter are sodden in water, and are then generally dragged off by the patient's friends in undressing him. This, however, ought always to be avoided when professional aid is early at hand; the clothes should be very carefully cut off, the bullæ opened by a small puncture, and the epidermis smoothed down gently upon the skin. It will, if carefully managed, generally remain there till the papillæ are protected by a fresh formation. When the burnt surface has been deprived of its epidermis, the papillæ usually furnish an abundant secretion of pus, and are distressingly irritable and sensitive. Sometimes the papillary tissue may slough from the resulting inflammation, even in cases where it is in no degree disintegrated by the injury. In other respects the treatment is the same as in burns of the first degree; the best plan, perhaps, being to apply some mild salve (such as calamine cerate) over the burnt surface, and then to wrap the part thickly in cotton-wool.

3. Burns of the third degree are much more serious than the two former varieties of the injury, since here a portion of the papillary tissue has been destroyed, and must slough; and its reproduction, if the extent involved be great, is usually a very tedious process, while during its progress the patient is of course liable to the various complications which may affect any open wound (erysipelas, phagedæna, etc.), as well as suffering from the weakness induced by protracted discharge. The best way of treating burns of this depth, is to dress the sloughing parts with some stimulant application, in order to hasten the separation of the slough. The best with which I am acquainted is the ung. elemi co. of the St. George's Hospital Pharmacopœia.[1] Or turpentine may be used in liniment, or mixed with an equal quantity of this ointment. Turpentine is a very valuable application in burns where the surface is sloughy, but is unnecessary and painful in those where it is raw and tender. Carron-oil (a mixture of equal parts of linseed-oil and lime-water) is a deservedly popular remedy [this preparation, which is commonly used in the Pennsylvania Hospital, seems to fulfil every indication as a primary dressing, and is very soothing; strips of patent lint, old soft towels, or canton flannel, after being thoroughly soaked in the mixture, are carefully and accurately applied; the whole is then covered with sheets of waxed paper, which not only insures greater cleanliness, but prevents evaporation]; and hosts of other stimulating substances are recommended. I have lately used in several cases, and I think with very good effect, the mixture of carbolic acid and linseed-oil, so highly recommended by Mr. Lister in the treatment of various injuries. Professor Pirrie also speaks highly of its use in burns.[2] The oil should be in the proportion of six to eight times the quantity of the acid. It seems to allay pain and obviate fetor better than any other application. The neighboring part, where the burn is less deep, may be dressed with some mild ointment; and the whole enveloped, until reaction is thoroughly established, in a thick layer of cotton-wool, loosely supported by a bandage. The dressings of a burn should never be changed more often than is absolutely requisite for cleanliness. As the slough loosens at the edges, its loose part should be cut away at each dressing; but it must not be forcibly detached. When it has separated, the exposed surface is left raw and suppurating; generally indented by small pits, from the unequal depth of the slough. The object now is to procure cicatrization as speedily as possible, since, if the inflammation proceeds unchecked, a crop of prominent, flabby, or fungous granulations will spring up, which are with difficulty brought to heal; or ulceration may proceed at the edges, and widen the sore. I believe the best plan will be to apply moderately firm pressure, as soon as it can be borne, by careful strapping. If the diachylon plaster be found too irritating, soap-strapping may be used, or the plan recommended by Mr. Chapman for ulcers of the leg (water-strapping). I believe, however, that adhesive plaster is the preferable material, and its use affords by far the most efficient and comfortable plan of treating large granulating burns. The strapping is not extremely painful at the time of application, does not require frequent removal, and does not necessitate confinement to bed. If this method be contraindicated, the sore must be treated on the general principles laid down in the essay on Ulcers; but it will be found almost inevitable to recur to pressure in some form, when the granulations have sprouted up and present an extensive suppurating surface, which shows no tendency to heal. Such cases go on for months, under every kind of treatment, even when the granulations look healthy. Sometimes the sore, after being healed for a shorter or longer period, will break out again from time to time; occasionally it remains incurable. In recent cases, repressing the granulations by pencilling either the edges, or, if necessary, the whole surface, with stick-caustic, and applying firm pressure with strapping, is the most efficient method of treatment. Sometimes it will be advisable to fix on to the granulated surface below the strapping a piece of thin sheet-lead, or of oiled silk, cut so as to fit the wound exactly; and it is frequently found beneficial, especially when the discharge is profuse, to dust the surface with some astringent, in fine powder, as starch, alum, calamine, etc.

[Cases of extensive ulceration formerly considered incurable, are now amenable to treatment by the aid of epidermic or skin grafting. This method, originally recommended by Reverdin, of Geneva, in 1869, answers admirably where there has been much loss of integument, and if persistently followed up, frequently prevents serious deformity. The ulcer should be brought into as healthy a state as possible before grafting. Transplantation of

[1] ℞. Unguent. elemi ℔j.; unguent. sambuci ʒij.; copaibæ ʒiij. Unguentis simul liquefactis et ab igne remotis, paullo antequam refrixerint, copaibam adjice.

The unguentum sambuci is another hospital preparation made of the leaves, in the proportion of 2 lbs. to 2½ lbs. of fat boiled down with water and strained.

[2] Lancet, Nov. 9, 1867.

skin as suggested by Wolfe, in 1876, has been successfully practised; especially good results have been observed when the operation has been performed for deformities about the eye-lids, the result of burns; the portion of transplanted integument is usually selected from the chest, arm, or fore-arm, and as far as practicable it should be free from subcutaneous adipose tissue.]

It is the opinion of some surgeons[1] that in burns which suppurate extensively, death is often due to the mephitic influence of the foul air which is so extensively generated in such injuries. In these cases, no better application can be used than Condy's ozonized liquid [solution of potassium permanganate], diluted in the proportion of from half a drachm to a drachm in a pint of water. This excellent disinfectant is now in very extensive use in all cases of foul discharge or fetid exhalation. It has also appeared to me to exercise a favorable influence on the progress of the indolent ulcerating surfaces of burns, apart from its disinfectant action; and thus I employ it frequently as a topical application to burnt surfaces in children.

4. The above observations will also apply to the treatment of burns of the fourth degree; but here a most important additional element enters into consideration, that of the contraction which will accompany and follow cicatrization. Those who have had even slight practical experience of these cases, need not be reminded of the frightful deformities thus induced: the head drawn down upon the shoulder, the jaw everted and fixed upon the breast, the lips turned out, clear articulation impossible, the dripping and distorted mouth, the rigid twisted limbs, and all the ghastly and hopeless mutilations which so often follow burns in the neglected children of the poor. Whenever, therefore, there is the slightest probability that the whole thickness of the skin has been involved in any part of a burn, cicatrization ought to be watched with the greatest care, especially if it be in a part where the integuments are loose, and where important organs would be interfered with by contraction, in order to obviate this result as far as possible, by the use of appropriate extending apparatus. This apparatus should be very carefully fitted, and maintained night and day in position till the burn has healed; and for some time afterwards, as the tendency to contract does not vanish with the healing of the wound. As long as any risk of contraction seems to be present, the scar should be kept stretched, and its extensibility be promoted by keeping it constantly saturated with oil. The ingenuity both of the surgeon and instrument-maker is called for in these cases, and much success is often obtained both in obviating and curing deformities. But many disappointing and hopeless cases will be met with, in which the use of extension cannot be tolerated on account of the pain and irritation it causes, or in which the patient's strength is so exhausted that he cannot bear the extra call upon it, which is of course necessitated by keeping the wound largely open; or in which the points where counter-extension should be made are themselves involved in the injury. In these we must allow contraction to occur, and only think for the moment of producing as speedy union as possible; or if a limb be the seat of the injury, and the resulting contraction will leave it useless, the first favorable moment for amputation must be chosen. The treatment of contracted cicatrices will be found described elsewhere (PLASTIC SURGERY).

Little need be added as to the treatment of burns of the fifth and sixth degree. The former, if of any considerable extent and seated on the trunk of the body, are almost necessarily fatal. When the limbs are the seat of injury, and the part involved is large, or when the fingers are burnt, and the consequent sloughing will destroy the action of the tendons and render the finger useless, it is better to amputate at once. Burns of the sixth degree, if the patient survive so as to become the subject of treatment, must be seated on the extremities. Practically they are hardly ever seen, except where the thickness of the soft parts is trifling, as on the fingers, dorsum of the hand, or foot, etc. Most of them require primary amputation; the necessity depending on the extent of the burn, and the conditions which will follow the separation of the sloughs.

It is hardly necessary to say anything about the indications for secondary amputation in burns on account of incurable ulceration, or contraction of the limbs, as these are questions rather of common sense than of precedent or theory; and where large joints are opened by the separation of the slough, the case does not differ materially from any other of gangrene with similar complication.

ACCIDENTS FROM LIGHTNING.

Accidents from lightning are very rare in this country,[1] and it has never fallen

[1] See a Clinical Lecture, by Mr. Mitchell Henry, in Lancet, Dec. 19, 1851, p. 580.

[1] M. Boudin calculates the number of deaths in England at twenty-two per annum; and the total of accidents at about double this number.

to my lot to witness immediately on their occurrence any which called for serious surgical treatment; nor does it seem to have occurred to those of our countrymen, whose experience of this form of injury in tropical climates may have been greater than ours, to give the profession any systematic account of the matter. I must therefore apologize for the necessarily secondhand character of what follows on this head. Sir Benjamin Brodie, in his Lectures illustrative of various Subjects in Pathology and Surgery, has treated the subject with his usual clearness and felicity; but only so far as to show the manner in which death is produced by a stroke of lightning, and the means to be used in order, if possible, to save life. The most complete account which I have been able to find of the minor, but still very serious, symptoms which sometimes follow these injuries, is contained in Boudin, Géographie Médicale, Paris, 1857, vol. i., p. 499 *et seq.* An abstract of M. Boudin's researches may be found in Althaus, Medical Electricity, London, 1859, Appendix. From these sources and from a number of cases recorded in old volumes of the Philosophical Transactions, the following account has been chiefly compiled.

A person struck by lightning is usually more or less completely deprived of consciousness at the time. This is a consequence sometimes of the shock given to the brain, and is accompanied by more or less paralysis of motion and of sensation, common or special. Sometimes, and perhaps more usually, it is the effect merely of fright, and is then only transient. The insensibility sometimes lasts for a considerable time; as in a case recorded by M. Boudin, in which a gentleman having been struck by lightning remained for an hour and a quarter without (as the bystanders affirmed) any sign of life, and then recovered on being exposed to a pelting shower of hail. The paralysis by which it is usually accompanied may last for an indefinite period. In the above case the patient did not entirely recover for more than four months; and in one recorded in the sixty-third volume of the Philosophical Transactions, weakness and numbness were still felt three months after the stroke. This paralysis is more common in the lower limbs than in the upper. Other affections caused by lightning are: burns, more or less extensive; eruptions of erythema or of urticaria, which are said by one author to have reappeared afterwards with each succeeding thunderstorm; loss of hair over parts or the whole of the body; wounds; hemorrhage from the mouth, nose, or ears; loss of sight, smell, speech, hearing, and taste, or, in rare cases, exaltation of these special senses; cataract; imbecility; abortion. Another curious effect of lightning, which is asserted by many independent authorities, though it is variously interpreted, is that it sometimes leaves arborescent marks on the body, even on parts covered by clothes, which have often been described as a kind of photograph of neighboring trees or other objects.

Many of the recorded cases of injury by lightning are very curious and interesting; but, as the foregoing list will show, the symptoms are too miscellaneous, and their method of production too obscure, to be brought under general rules; and it would lead us too far from ordinary practice to attempt to dwell minutely upon them. It may suffice to say that persons not killed on the spot usually [eventually] recover, though a few cases are on record in which they have died of exhaustion; and that recovery is apparently hastened by the administration of tonics, especially quinine, and gentle action on the skin by means of baths. In the case of protracted convalescence already referred to, the patient on coming to himself found that he had completely lost the sense of sight, and that he could hardly feel any of his limbs, and could not move them. He was also severely burnt on various parts of the body. In this case, as the power of motion and the sense of sight returned, the patient was tormented with pains in the limbs and head. These were relieved by galvanism, which was thought also to have hastened the healing of the sores left by the burns. The loss of hair, which is sometimes produced by the action of lightning, is a phenomenon more commonly noticed in the lower animals, who, it may be remarked, are much more exposed to damage in thunder-storms than human beings, even under the same circumstances. Sir B. Brodie has referred to a curious story, in the Philosophical Transactions, of two bullocks, pied white and red, who were struck in different storms. In both cases the white hairs were consumed and the red escaped. The following anecdote, however, related by M. Boudin, shows that in men also loss of hair is sometimes produced by flashes of lightning. The frigate Golymin was struck by lightning on the night of February 21, 1812, and the captain, M. Rihouet, received several wounds on the head. "The next day," says that officer, "when I went to shave myself, I found that the beard, instead of being cut, was torn out by the action of the razor; and since that day it has totally disappeared. The hair of the scalp, eyelashes, eyebrows, and surface of the body fell off successively. Since then I have remained entirely hairless. During the year 1813, the nails of my fingers

scaled away. Those of the toes experienced no visible change."[1]

The burns caused by lightning are sometimes deep and very obstinate in healing;[2] sometimes, on the contrary, they amount merely to vesication, or even only to discoloration. They will be treated on ordinary principles, unless indeed the authority of the case above alluded to should induce the surgeon to make trial of the effects of electricity, which is said sometimes to produce the healing of ulcers due to other causes, which have resisted the ordinary modes of treatment.

Mutilations of the body are only rarely met with. Out of a large number of fatal cases, M. Boudin has only found six in which mutilation is noticed to have occurred; and it is a singular circumstance that in four of these the tongue was the part affected. Wounds and fractures, especially of the skull, are sometimes, but rarely, noticed.

The post-mortem appearances in cases of death by lightning vary extremely. The body sometimes retains the attitude in which it was when struck. Thus a case is related in which a man was killed on horseback, and the horse proceeded some distance with the dead rider still in the saddle. At other times the body is thrown to a considerable distance. The clothes are often burnt or torn, even when the surface of the body is not injured. In respect of muscular rigidity, opinions, and probably facts, vary also. John Hunter taught that "animals killed by lightning, and also by electricity, have not their muscles contracted;"[3] but this is certainly inconsistent with common experience, although it may be the fact in exceptional instances. Thus in Dr. Richardson's work on the Coagulation of the Blood[4] may be found the account of an experiment performed on a large dog, which was killed by a powerful electric current. In half an hour rigor mortis commenced, and increased to such an extent that "in five hours the dog appeared as if frozen hard,[1] or carved out of wood, being quite stiff and inflexible." The same author (p. 138) makes death by electricity the only exception to the rule that in cases of immediately sudden death the blood coagulates "with moderate firmness and in the ordinary mode." To the same effect is a case reported in the Philosophical Transactions, vol. lxiii., p. 177, where a man was struck dead while in bed. A doctor was sent for, who, at the request of the patient's wife, opened a vein in the arm. The blood was so fluid that it continued to ooze out till the man was put in his coffin. M. Boudin, however, says that the blood is sometimes found coagulated; and Sir C. Scudamore's experiments prove the same fact in animals killed by electricity.[2] The heart is usually, as it seems, flaccid and empty. The condition of the lungs seems very uncertain. Putrefaction may be sometimes hastened, but is more often retarded.

Death is caused in immediately fatal cases by the shock to the brain and nervous system, and perhaps in some rare instances by asphyxia; and it appears impossible to express the indications for surgical treatment in these cases more clearly and succinctly than they are thus given by Sir B. Brodie: "Expose the body to a moderate warmth, so as to prevent the loss of animal heat, to which it is always liable when the functions of the brain are suspended or impaired, and inflate the lungs, so as to imitate natural respiration as nearly as possible."[3] It may be added that these attempts to restore animation should not be too soon given up, since stories are on record (one of which has been quoted above) of the return of animation after its apparently complete suspension during more than an hour. Cold affusion, stimulating enemata, and stimulants administered by the mouth [inhalation of nitrite of amyl?] will be appropriate adjuvants to this treatment, especially in the less severe cases. The prognosis is generally favorable, as far as the recovery of life goes, in cases not instantly fatal; and even when some of the special senses are temporarily abolished, their restoration is not hopeless.

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[1] Œuvres de F. Arago, Paris, 1854, tom. i., p. 377.

[2] Cases are reported in which the entire bodies of men and animals have been reduced to ashes; but such events (if indeed they be not mere exaggerations) must be very rare.

[3] Works, by Palmer, vol. iii., p. 114.

[4] Astley-Cooper Prize-Essay, p. 96.

[1] This may account for the fact that persons killed by lightning have sometimes been described as presenting all the appearances of having been frozen.

[2] Taylor's Med. Juris., art. "Lightning."

[3] Op. cit., p. 104.

ANIMAL POISONS.

By Alfred Poland, Esq.

Revised by Samuel Ashhurst, M.D.

Under the category of poisoned wounds is comprised a series of important lesions, which attack the human species through the medium of some peculiar and specific poison, emanating from a body with which the individual has been placed in contact; a poison acting on the blood, contaminating the constitution, and developing distinct and special symptoms.

This may be derived from the mineral, vegetable, or animal kingdom; but it is to the latter class only that we shall now direct attention; and in so doing we shall necessarily have to exclude some of the contagious and infectious animal poisons, such as syphilis.

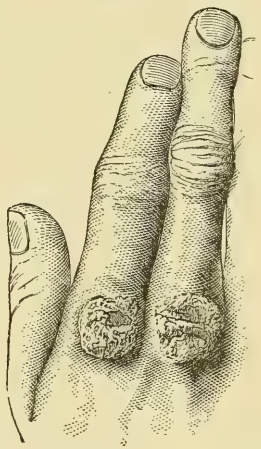
The animal poisons, affecting man through the medium of a wound, may be derived from the following sources: 1. From the dissection of recently dead bodies; 2. From the sting or bite of healthy animals—such as insects, serpents, etc.; and 3. From the bite of, or inoculation by, diseased animals—such as from the dog, causing hydrophobia, or from the horse, glanders.

1. *Poisoned wounds derived from the dissection of recently dead bodies.*

Wounds from dissection are not ordinarily attended with any peculiar and specific disease; they are commonly followed by those affections which are generally met with in incised and punctured wounds inflicted by clean and innocuous instruments. Thus, any form of wound under certain conditions and circumstances may be attended with absorbent inflammation, attacking the deep as well as the superficial glands; inflammation of the subcutaneous tissues of every possible variety; inflammation of the thecæ and tendinous structures; or their secondary effects, such as suppuration, hectic fever, pyæmia, gangrene, etc. All these accidents and affections need no comment in this place.

There has been described under the term "anatomical tubercle," or verruca necrogenica,[1] a condition of the hands and fingers due to the constant contact with the morbid fluids of dead bodies. It consists in a chronic thickening of the skin, and may be followed by a peculiar form of furunculus. It either begins as an active

Fig. 71.



Anatomical tubercle. Model Guy's Mus. 1935[0].

pustule arising from absorption by the skin, or takes its origin in a wound: the morbid change is a slow one—a warty thickening of the epithelium, which in course of time becomes of a dark color and fissured, until a kind of ichthyotic condition is produced. Some affirm that they have met with these tubercles in persons who have not been exposed to this agency.

This affection will usually disappear under the repeated use of the acid nitrate of mercury, or strong nitric acid, to the affected skin.

But in rare and isolated instances, dissecting-wounds are attended with serious symptoms, often leading to fatal results. Two forms have been recognized, the *mild* and the *acute;* these, however, only indicate, that in the one instance the poison is of a mild character, and the constitution sufficiently strong to counteract and withstand its effects; while in the other, the dose of the poison is intense, and, being developed in an over-susceptible in-

[1] Wilks, Guy's Hosp. Rep., Series III., vol. viii., p. 263.

dividual, of generally feeble power, is followed by a speedily fatal termination

The symptoms in the mild form partake more or less of the ordinary characters of non-specific inflammation, and often present scarcely any noticeable characteristic signs: thus, the local appearances consist in the puncture assuming a defined red aspect, which soon becomes pustular; this bursts, and ends in an unhealthy suppuration; there is surrounding erythema, of an erratic form, and inflammation and pain extending along the forearm and arm to the axilla, ending in the enlargement and suppuration of the glands. The constitutional effects consist in febrile disturbance, loss of appetite, diarrhœa, fetid eructations and breathing, etc. The prognosis and termination are favorable; and the treatment required is to be based upon general principles.

The symptoms of the acute or severe forms are those of a truly specific disease; the local signs commence by the appearance of a small circular or oval vesicle over the seat of puncture, which soon becomes turbid, milky, and pustular, and not unfrequently has a defined margin resembling somewhat that of smallpox; this is generally unattended with pain; but the patient often complains of intense pain in the shoulder and about the axilla, which shoots down the chest. The glands in the axilla are early affected, and seem to act as barriers to the further progress of the poison; they become enlarged, and the surrounding cellular tissue is implicated, with serous effusion; there is erythema and puffy swelling. These extend to the subscapular and pectoral regions, spreading down the side of the chest, yielding to pressure, and imparting a peculiar spongy feel. There is, besides, an œdematous and doughy condition of the arm and forearm, owing to serous exudation into the cellular tissue, and seldom, if ever, passing into suppuration.

The local symptoms are well exemplified in the case of Professor Dease (Dublin Hosp. Rep., vol. iii.). "His demonstration took place on a recent subject, and he awoke early the ensuing morning with severe rigors, sickness, and acute pain in the left shoulder. On the next day a fulness was observed above the clavicle, along the left side of the neck, which could not bear the slightest pressure. On the day succeeding a colorless swelling was noticed about the axilla, which first suggested the real nature of the complaint; and on examining the hand, there was found by Dr. Colles the mark of a slight scratch with a superincumbent vesicle. He appeared to improve a little for a day or two, though full, florid, and crimson erythema occupied the side in the region of the pectoral muscle, extending downwards. On the morning of the sixth day he showed symptoms of delirium; and a vesicle appeared on his forearm, which remained stationary to the last. By the next day the erythematous swelling had extended over the entire side of the body, from a little below the axilla to the hip; and the swollen part became studded pretty thickly with indurated papulæ; the delirium was more confirmed. On the eighth day the inflammation completely involved the axilla, and on its posterior edge an abscess seemed to have formed, though there was no fluctuation. At this period the opposite or right arm exhibited an intumescence on its anterior part, occupying about a hand's-breadth of the flexor muscles, which was punctured on the same evening and discharged about a teaspoonful of serous fluid, but without relief; and within an hour or two afterwards, being the eighth day from the accession of the disease, he expired."

The constitutional symptoms are at first those of strong excitement; but these are soon followed by those of extreme depression of spirits, and much suffering. Rigors, headache, prostration of strength, vomiting, etc., supervene; and, lastly, all the symptoms of low typhoid fever rapidly set in.

In the case of Dr. Pett, quoted by Travers (On Constitutional Irritation), the symptoms on the third day were "a haggard and depressed countenance; violent shiverings, followed by some degree of heat; extreme alteration in appearance; countenance suffused with redness; the eyes hollow and ferrety; some difficulty of breathing, which was sudden, irregular, and amounting almost to sighing; excessive torpor, and the whole aspect resembling one who had taken an overdose of opium; on the following day there was extreme exhaustion and feebleness, and death ensued on the fifth day."

There are several deviations from the foregoing description: thus, in some cases, the poison may enter the system without involving the absorbent glands; in others, death may ensue from precursory fever, before the appearance of any severe local disease, as in the case of Mr. Ellcock.[1] Again, the symptoms may be attended with diffused suppuration and pyæmia; in some gangrene or sloughing of the integuments and cellular tissue may ensue. These circumstances depend for the most part on the acuteness and strength of the local action, and the previous habits and condition of the patient.

The diseases with which this affection is liable to be confounded are acute rheumatism and absorbent inflammation; but the history of the case, the peculiar pustular eruption, the blush and effusion over the pectoral region which are so frequently present, the low typhoid fever,

[1] Travers, On Constitutional Irritation.

and rapidly fatal termination, will assist us in recognizing the disorder.

The prognosis is generally unfavorable; and it is affirmed by Travers that one only in seven recovers. When death does not take place immediately, large sloughs and purulent depôts render the recovery tedious and protracted, taxing the patient's constitution to its utmost.

The morbid appearances include the different grades of diffuse cellular inflammation, and the morbid effects of poisoned blood.

Respecting the pathology various opinions have been expressed. Some attribute the disease to an irritation and inflammation of the simple kind, affecting a constitution and idiosyncrasy of peculiar excitement; others, to the absorption and irritation of a putrescent fluid, as suggested by Majendie: but this explanation will hardly account for the frequency of the disease after contact with recent bodies before putrefaction has set in. Again, others consider the cause of the disease to be a specific virus, acting primarily on the blood and rapidly involving the nervous system, its effects mainly depending upon the quality of the poison and the susceptibility of the individual. The arguments brought forward in favor of this view are the following: the plurality of persons affected at the same time, from the same body, and with the same symptoms;[1] its frequency after dissecting recent subjects, and more especially subjects who have died of acute diseases, such as puerperal fever, peritonitis, etc.; its occasional occurrence without any local affection whatever; and, lastly, although rarely, its existence without wound or abrasion.

Billroth says: "Is it a septic poison or purulent infection? It is not true that it is entirely due to the absorption of fluid from a dead body." He attributes it chiefly to a form of pyæmia or purulent infection of the blood—a pus poison; which may be followed by true erysipelas, lymphangeitis, lymphadenitis, and a form of phlegmon, but very seldom by furunculi or phlebitis. He also relates cases of this disease derived from dead or necrosed tissues of the living body, and states that the worst case he ever saw occurred to the Professor of Surgery, who met with a scratch in attempting to extract a sequestrum which was saturated with fetid pus—lymphangeitis followed and then suppuration of the axillary glands, succeeded by pleurisy; and recovery only ensued after a very severe and dangerous illness.

Treatment.—There are two modes advocated according to the views taken of the pathology: the one consisting in constitutional antiphlogistic treatment, without much reference to local measures; the other in the use of local measures, and keeping up the powers of the patient, without resorting to the depressing influences of local and general depletion with calomel and antimony. The latter method is the one now universally preferred. The local applications, if used at all, must be employed immediately, decisively, and effectually. Should a person be in bad health at the time of receiving a prick or wound during dissection, no matter what condition the subject be in, it behoves him to pay immediate attention to the injury, and anticipate any further consequences; but should the wound be received whilst engaged on a recent subject and one which had died from acute dis, ease, much more caution and attention is required, even if he be in the best of health. The part should be well cleansed, and a temporary ligature applied immediately above the wound; then the bleeding, if any, should be encouraged to flow freely: where there is no bleeding, suction must be employed. After such preliminaries, caustics are to be applied freely to the punctured wound, which may be enlarged if necessary; the nitric and sulphuric acids, nitrate of silver and chloride of zinc, are generally recommended. Directly there is any irritation or inflammation in the site of the wound, a free incision must at once be made, and bleeding encouraged; and should there be a tendency to erythematous extension, a circular line may be made around the part with the nitrate of silver, so as to prevent any further spreading. When the disease has fully set in, warm fomentations, and incisions where required, must be had recourse to.

[The immediate and continuous application of a poultice or warm-water dressing, by promoting the escape of blood and other fluids, will very often prevent the infection, either local or general, which would otherwise ensue.]

So soon as the constitution begins to suffer, immediate removal to country air is absolutely necessary, and the powers of life must be kept up by tonics, stimulants, sedatives, etc., as the case may require. But fresh air and good nourishing diet will do more in combating the effects of the poison than trusting solely to medicinal measures. Calomel and venesection are to be sedulously avoided.

2. *Poisoned wounds from healthy animals; the stings of insects, bites of serpents, etc.*

With regard to poisoned wounds produced by the bites and stings of insects

[1] See the case of Dr. Cumming, quoted by Dr. Duncan in the Med.-Chir. Trans., Edinb., vol. i.

little need be said; these are for the most part attended by mild symptoms, and are cured by simple topical remedies. In bees and wasps the sting is generally left in the wound, and should be extracted with care, and the after-irritation allayed by the application of cold or stimulating lotions, or protection from the air by means of flour, chalk, etc. Sometimes through accident, as in eating fruit, the insect may be swallowed, and in its passage through the fauces may excite a severe and diffused inflammation, which may extend to the glottis and produce impending suffocation: this must be treated promptly by scarifications, leeches, and the ordinary appliances of surgical aid. The scorpion is the only insect recorded to have any virulent poison, but its malignity in Europe is said to be trifling as compared to that which is experienced in Africa and in the East; and even in these countries it is said by some to cause no material injury. The tarantula bite is attended with no dangerous symptom, and will readily heal; the wonderful stories respecting its virulence are unfounded.[1]

Poisoned wounds from the bites of serpents are much more formidable; they are occasioned by a class of serpents termed venomous, which have a special apparatus for secreting a poison at the base of the upper fangs, by which they are enabled to inflict an injury and produce the most serious and dangerous symptoms, in some instances causing speedy death.[2]

The viper is the only poisonous reptile in England; but in other parts of the world there are several, such as the rattle-snake, the whipcord-snake, the phoorsa-snake of the East Indies, the cobra di capello, etc. Some of these are brought to this country for exhibition, and now and then fatal instances are witnessed of the effects of their bite on man.

The bite of the viper is attended with the mildest form of symptoms, and the effects are seldom, if ever, fatal in this country.

The symptoms generally observed in poisoned wounds by venomous serpents are the following:—

Immediately there is more or less hemorrhage from the wound, and shortly after the bite there is a pricking, burning pain, extending rapidly upwards and becoming very acute. These symptoms, however, are not always constant. Soon afterwards the part and limb almost inevitably swell and very rapidly, accompanied with a discoloration of the skin, not due to inflammation, but, according to Mitchell,[1] due to a large or small collection of effused blood about the wound and cellular tissue; its amount depending upon the tissue in which the wound is inflicted. These local symptoms increase progressively, extending upwards and attended with the most excruciating agony. The extremity becomes larger and more and more discolored, until the skin offers every tint of an old bruise; thus the limb at first may assume a dark red appearance, or be merely of a pale white color; but as the disease advances, a series of abnormal colors are met with, passing from red to pale white, and from pale white to a blue, violet, gray, leaden, or marble hue. The secondary effects soon make their appearance in the shape of inflammation and disorganization. The inflammation may take various forms: in some, a diffused inflammation of the cellular tissue; in others, a superficial erysipelatous condition; in others, absorbent inflammation; in others, a local phlebitis; and in others, a plastic fibrinous effusion, or an œdematous infiltration, or an effusion of sanguineous material, giving an appearance of ecchymosis. The glands in the axilla are generally enlarged and involved early when the upper extremity is the part wounded, and the glands in the groin when the bite is in the lower extremities. These glands inflame and suppurate, and form sinuses and fistulous openings. The limbs become stiff and difficult to move from infiltration of the cellular tissue be-

[1] Mr. Turnbull says: "I took some pains in inquiring into the effects of the sting or bite of the tarantula. The diseases said to proceed from these bites are such as are caused by summer-heats in all southern countries. The reapers are the most subject, and the epidemic at that time is ague or intermittent fever, and the cure is effected by dancing to music for a considerable time, till a sweat is brought on and weakness follows. He is thus assisted in the exercise by friends and a free use of cordial wines, when profuse sweating and rest and sleep follow, and a cure is effected. . . . The Archbishop of Otranto assured me that it was a ridiculous, vulgar notion, full of imposture and prejudice, and entirely void of foundation." Essays and Obs., Physical and Literary, Edinb., 1771, vol. iii., p. 104.

[2] For a description of the venomous serpents, see Vol. III.

[1] Researches upon the Venom of the Rattlesnake, with an Investigation of the Anatomy and Physiology of the Organs concerned. S. Weir Mitchell, M.D. Philadelphia, July, 1860.

On the Treatment of Rattlesnake-bites, with experimental Criticisms upon the various Remedies now in use. Philadelphia, 1861.

Experimental Contributions to the Toxicology of Rattlesnake Venom. New York Medical Journal. January, 1868.

tween the muscles. Phlyctenæ and bullæ appear on the surface, filled with sanious fluid. The part grows livid and cold, gangrene and sphacelus set in.

The constitutional symptoms are early and rapidly developed. There is general derangement of the nervous system, evinced by terror, great anxiety, depression, and prostration; profuse cold sweats, difficulty of breathing, vomiting, bilious stools, a universal yellowness of the skin, excruciating pain at the navel and rapid death. In bites from the rattle-snake and the cobra, the local and constitutional symptoms take place nearly simultaneously; the vital principle is from the first exhausted suddenly, as though by a stroke of lightning; the blood ceases to flow in the smaller vessels of the swollen part; the superincumbent skin feels deadly cold; the action of the heart is so weak that the pulse is scarcely perceptible; the stomach so irritable that nothing can be retained on it; dejection and horror overpower the mind, and a low muttering delirium closes the scene. In the case of one of the keepers of the Zoological Gardens, who was bitten on the bridge of the nose by a cobra a few years ago, half an hour only had elapsed when he was apparently dying, being unable to speak, swallow, or support himself; the pupils were dilated, face livid, heart's action feeble, and he was scarcely conscious. Death took place in little more than an hour from the infliction of the wound. An interesting case of prolongation of life for nineteen days after the bite of a rattlesnake is recorded by Sir E. Home in the Philosophical Transactions for 1810.

The prognosis is unfavorable; rapid death is the general result; but should recovery take place, it will be very protracted, owing to the large amount of surface injured, and the immense call upon nature's power of repair, often overtasking it, and finally leaving the limb useless, either from stiffness of the joints, or adhesion of the muscles in one uniform mass.

In some instances the recovery has been sudden and complete; so abrupt as to form a striking contrast to the severity of the constitutional symptoms. At one moment the patient was considered moribund and shortly afterwards the symptoms all passed off, and he was able to pursue his ordinary avocation, thus resembling the action of the vegetable poisons. The most rapid death in the cases cited by Mitchell was five and a half hours; one patient died comatose, another with dyspnœa and dysphagia, and a third felt sleepy and died without agony. Sir E. Home's patient died on the seventeenth day with well-expressed typhous symptoms.

The morbid appearances in the bodies of persons dying from serpent poison have seldom been noticed: it is, however, stated that there is generally muscular rigidity; the body is more or less swollen and abnormally colored, at times presenting bullæ and unhealthy ulcers; the head and brain often contain much serum, and there is much increase in the cerebro-spinal fluid; the lungs are dark and congested, and the heart either empty, or filled with much dark blood.

Mitchell found, among the most constant and most curious lesions in the cases which he classes as secondary poisoning, ecchymoses on and in the viscera of the chest and belly; most frequently affecting the intestinal canal, though they may and do occur in any cavity and on any organ. These spots contain blood whose globules are more or less deformed, but still of dimensions not less than usual. As they do not take place until the blood is considerably altered, and as the intravascular blood-discs undergo no apparent change, this leakage of the blood into the serous cavities and areolar interspaces is plainly due to the loss of coagulating power in the blood, or to alterations in the vascular tubes, or perhaps to both.

The rapid decomposition of the blood and of the tissues locally acted upon by the venom, leaves no doubt about the astounding septic or putrefacient power of the poison; and makes it apparent that an incipient putrefaction of this nature may so affect the blood as to destroy its power of clotting, and perhaps also of nourishing the tissues through which it passes.

In the acute and rapidly fatal cases, where the symptoms of depression are most marked, and the heart and nerve-centres are suddenly and fearfully enfeebled, the venom appears to have a specific influence on these, such as is observed in the better known poisons, as woorara, upas, corroval, opium, aconite, etc. May it be possible that an imperceptible change occurs in the blood, the composition of which is so fatally altered as to produce the loss of irritability in the nerve-centres? If such be the case, then the suddenness of the general change of the blood must account for the failure of life.

Mitchell concludes from the results of observation and experiments:—

1. That the heart becomes enfeebled shortly after the bite, and that this is due to the direct influence of the venom on this organ, and not to the precedent loss of the respiratory function. The heart continues in motion until after the lungs cease to act; and its tissues remain for a time locally irritable.

2. That in warm-blooded animals artificial respiration lengthens the life of the

heart, but does not sustain it so long as when the animal has died by woorara or decapitation.

3. That in warm-blooded animals, respiration ceases, owing to paralysis of the nerve-centres.

4. That the sensory nerves, and the centres of nerve power in the medulla spinalis and oblongata, lose their vitality before the efferent or motor nerves become affected.

5. That the muscular system retains its irritability in the cold-blooded animals, acutely poisoned, for a considerable time after death.

6. That the first effect of the venom being to depress the vital energy of the heart and nerve-centres, a resort to stimulants is clearly indicated, as the only rational mode of early constitutional treatment.

The effects of the poison seem to cause an altered condition of the blood. In bites from the phoorsa-snake, in India, there is noticed a hemorrhagic tendency during life. In the rapid death from the bite of the cobra, above cited, all the phenomena of asphyxia were present, and death was supposed to have resulted from the poison paralyzing the medulla oblongata, and those portions of the nervous system that are instrumental in carrying on respiration, at the same time that the blood was disorganized by the action of the virus.[1]

Mitchell divides the effects of venom poisoning into two categories: the first, immediate, primary, or acute crotalus-poisoning, acting directly on the heart and nerve-centres; and second, the chronic or secondary form of poisoning acting through an altered condition of the blood. He enters with minuteness into the effects of the venom on the blood, both in and out of the body, and his results are thus stated:—

Effects of Venom on the Blood.—The study of the vital fluid in cases of acute or primary poisoning is of a merely negative value. An animal, especially a warm-blooded animal, which dies within a minute or two, or after even a longer time, presents us with none of those profound alterations of the blood which characterize all instances of secondary poisoning.

In the *primary* poisoning, the blood is red and coagulates perfectly; its corpuscles are ideally healthy; the tissues and fluids beyond the wound are pathologically as after poisoning by woorara or opium.

In the *secondary* poisoning, the physical character of the blood is that it is very dark in all parts of the body, but somewhat redder in the left than in the right side of the heart. Both the color and the accumulation in the veins seem to be due to the apnœa which ushers in death. The longer the death is delayed, the more apt is the blood to become incoagulable.

What is the effect of the direct mixture of blood and venom? What becomes of the fibrin in venom poison? What is the cause of the change in the condition of the fibrin?

The mixture does not alter the vital fluid at first in any way which is appreciable to our senses. Blood mixed with venom clots as firmly as usual, but after a time a catalytic change is induced, the clot softens, and even becomes perfectly redissolved, when the amount of venom is large, and the temperature of the atmosphere high. This finds its illustration within the system in cases of chronic poisoning, in which the fibrin of the blood loses its power of coagulation.

This change is produced by extensive putrefactive alteration in the blood, and is most readily induced in the blood of such persons as are anæmic.

In primary or acute poisoning, Mitchell was never able to detect the least alteration in the blood-cells, and in a few rare cases of secondary poisoning, he found a small proportion of the globules altered and indented on the edge, but in no case very remarkably so.

It was clear that in slow venom-poisoning the blood-plasma becomes profoundly altered.

1. In animals which survive the poisoning for a time, the blood is so altered as to render the fibrin incoagulable.

2. Experiments in and out of the body prove that this change is gradual, and that the absence of coagulation is not due to checked formation of fibrin, but to alterations produced by the action of the venom in that fibrin which already exists in the circulating blood.

3. The influence thus exerted is of a putrefactive nature, and imitates in a few hours the ordinary results of days of change. It is probably even more rapid within the body, on account of the higher temperature of the economy.

4. The altered blood retains its power to absorb gases, and thus to change its own color.

5. The blood corpuscles are unaffected in acute poisoning, and are rarely and doubtfully altered in the most prolonged cases which result fatally.

6. The contents of the blood globules of the guinea-pig can be made to crystallize, as is usual after other modes of death.

Professor Halford, of the Melbourne University, has directed his attention to the state of the blood after death from poisoning by the cobra, and in all cases found it dark, very fluid, without any tendency to coagulate on exposure. He found it to contain a large number of foreign cells, which, when highly magnified under the microscope, were seen to contain nuclei. His own words will probably best describe them:—

"When a person is mortally bitten by the cobra di capello, molecules of living 'germinal' matter are thrown into the blood and speedily grow into cells, and as rapidly mul-

[1] Interesting observations, by Dr. Fayrer, on the action of the cobra poison have been published in the Edinburgh Medical Journal and elsewhere.

tiply, so that in a few hours millions upon millions are produced at the expense, as far as I can at present see, of the oxygen absorbed into the blood during inspiration; hence the gradual decrease and ultimate extinction of combustion and chemical change in every other part of the body, followed by coldness, sleepiness, insensibility, slow breathing, and death.

"The cells which thus render in so short a time the blood unfit to support life are circular, with a diameter on the average of $\frac{1}{1700}$ of an inch. They contain a nearly round nucleus of $\frac{1}{2800}$ of an inch in breadth, which when further magnified is seen to contain other more minute spherules of living 'germinal' matter. In addition to this, the application of magenta reveals a minute colored spot at some part of the circumference of the cell. This, beside its size, distinguishes it from the white pus or lymph corpuscle.

"Thus, then, it would seem that as the vegetable cell requires for its growth inorganic food and the liberation of oxygen, so the animal cell requires for its growth organic food and the absorption of oxygen. Its food is present in the blood, and meets it in the lungs; thus the whole blood becomes disorganized, and nothing is found after death but dark fluid blood, its fluidity indicating the loss of fibrin, the dark color its want of oxygen, which it readily absorbs after death."—Pharmaceutical Journal, 2d series, vol. ix., p. 123.

Halford thus sums up his views:—

"The molecules of living germinal matter are thrown into the blood from the venom, and speedily grow into cells, and multiply so that in a few hours millions are produced, I suppose at the expense, as far as I can at present see, of the oxygen absorbed in inspiration. Hence, it seems, arise asphyxia and death."

In reference to this, Mitchell says: "Of course I cannot show absolutely that the venom of the cobra and that of the rattlesnake are alike in their mode of action. Since, however, those of the viper, rattlesnake, and copperhead are certainly identical in the form of their toxic activity, and since the glands are also alike and similarly placed in all venomous snakes, it is pretty sure that the cobra does not enjoy any peculiarity in the way of poisoning. The venom of the rattlesnake contains no germinal vesicles; and, as the blood of envenomed animals who live an hour or two becomes incoagulable, all of the white corpuscles are allowed to collect in multitudes at the top of the blood, and are the only bodies approaching the description which Professor Halford gives of his own oxygen-feeding cells. Still, as he insists that what he saw were not white corpuscles, I can only say that no such cells as his are seen after crotalus poisoning. The victim's blood is fluid if he survives long, and the red corpuscles are unaltered."

The treatment, locally, will be the same as that recommended in dissecting-wounds, only it is imperative that it should be adopted at the moment of receiving the bite; the immediate application of a ligature above the wound to prevent absorption, the excision of the bitten part, or the destruction of the poisoned surface by escharotics, are to be employed. The rubbing of the limb sedulously with olive oil is said to have been successfully had recourse to.

The constitutional measures comprise the following directions: to avoid the use of remedies which tend to increase the fluidity of the blood, such as calomel, alkalies, etc.; to counteract and get rid of the effects of the poison by the action of medicines; of these, numerous so-called specific remedies have been recommended, as adopted by inhabitants of the countries where poisonous serpents abound—viz., guaco, the sacra vitæ ancora; radix corineæ; decoction of the Virginia snake-root; the Tanjore pill, whose chief ingredient is arsenic, etc. The exhibition of stimulants and spirits in large doses, ammonia, etc., has been advocated, and used with beneficial effect, inasmuch as they counteract the great vital prostration. Arsenic has been given in several cases with success, and has been employed in the shape of Fowler's solution in two drachm doses every half-hour for four successive hours. Iodine also has been used successfully in poisoned wounds from the phoorsa-snake. Olive oil has been given internally, and much recommended.

Should the patient rally from the immediate effects of the poison, we must keep up the powers and combat the succeeding symptoms by means of tonics and support.

Halford's experiments induced him to believe that ammonia injected into the veins would counteract the virus of deadly serpents. He maintains that the poison renders the blood inert and sluggish, disposes it to coagulate, and causes morbid changes which soon entirely alter the appearance of the corpuscles. Ammonia prevents coagulation, arrests the stagnation of the vital fluid, awakens the action of the nerves, and stays the process of deterioration.

He forwarded the details of three cases to Mr. Paget[1] which had been successfully treated by this means; he recommends the liquor ammoniæ fortior to be diluted with two or three times its bulk of water, and of this mixture from twenty to thirty drops to be injected into one of the large veins near the bitten part.

In the three cases the wound was sucked at the time, and a ligature applied above the part, and stimulants administered; in one the part was excised, and in two scarified only; in all strong ammo-

[1] British Medical Journal, p. 104. January 30, 1869.

nia was applied locally. Subsequently ammonia was injected into the veins by a fine syringe.

A writer suggests that in medicine, *post hoc* must never be taken for the same thing as *propter hoc;* may not these cases have rallied by means of natural forces, from the first remedies applied and used; or may not the poison impregnated have been insufficient to kill?

A group of birth-worts, known to botanists as the Aristolochia Indica, have been considered specifics, as also the application of the celebrated snake stone, said to be made of charred bone.[1]

Dr. Mitchell thus sums up the treatment:—

1. The surrounding of the part bitten on the cardiac side with a ligature, so as to detain the poison and prevent its being carried into the circulation.

2. The removal of the part by excision or amputation, or the free use of the hot iron or powerful escharotics, so as to destroy or remove the poison.

Immediate suction of the part should be resorted to, and no danger need arise, as Dr. Mitchell has undoubtedly proved that mucous membranes cannot absorb the poison unless abraded. Cupping glasses may be made use of when at hand.

3. The injection into the wound or the application of iodine, alcohol, ammonia, etc., so as to neutralize the poison or render it innocuous. Dr. Mitchell recommends intermittent ligations and successive applications of the stimulants.

4. The local application of indigo or olive oil, the latter of which is much used and said to be successful among the natives.

At the same time we must give the patient reassurance, for not every bite is deadly, as there may be some accidental circumstance which may have prevented inoculation; and keep up the powers and restore the heart's action, which is generally so speedily depressed, by means of alcohol; recollecting that the persons affected are capable of bearing extraordinary doses of powerful medicines.

The sulphite or hyposulphite of soda or lime has no antidotal power.

Carbolic acid sometimes delays the fatal result and usually lessens the local hemorrhage. It has no value as a true antidote, and when given internally does not affect the ordinary fatal issue.

3. *Poisoned wounds derived from diseased animals.*

Of these we shall only allude to two classes—viz., hydrophobia and glanders.

[1] Wood's Natural History (vol. i., p. 142) contains a full and interesting account of these remedies.

Hydrophobia.

This term signifies the "dread of water," and is used to denote a disease in which that symptom forms one of the most prominent, constant, and marked characters.

The name has been objected to in consequence of the occasional absence of this pathognomonic sign, and of its presence in other diseases; hence it has been proposed to substitute the term *rabies* or *rage*, which also constitutes one of its distinguishing features, and *lyssa*, the Greek specific name for the madness of dogs. The disease, however, is generally known in this country as hydrophobia, and we have therefore adopted this term.

Hydrophobia consists essentially in the inoculation of the human body with the saliva of a rabid animal, which produces certain characteristic symptoms, always terminating in speedy death. Before adverting to these symptoms in man, it behooves us to consider well the disease as it affects the dog, from which animal the poison is most frequently derived.

Mr. Youatt's[1] description has been the one most uniformly accepted and quoted. He says: "The disease manifests itself under two forms: the *furious* form, characterized by augmented activity of the sensorial and locomotive systems, a disposition to bite, and a continued peculiar bark. The animal becomes altered in habits and disposition, has an inclination to lick or carry inedible substances, is restless and snaps in the air, but is still obedient and attached. Soon there are loss of appetite and the presence of thirst, the mouth and tongue swollen; the eyes red, dull, and half closed; the skin of the forehead wrinkled; the coat rough and staring; the gait unsteady and staggering; there is a periodic disposition to bite, the animal in approaching is often quiet and friendly, and then snaps; latterly, there is paralysis of the extremities; the breathing and deglutition become affected by spasms; the external surface irritable, and the sensorial functions increased in activity and perverted; convulsions may occur. These symptoms are paroxysmal, they remit and intermit, and are often excited by sight, hearing, or touch.

"The *sullen form* is characterized by shyness and depression, in which there is no disposition to bite and no fear of fluids. The dog appears to be unusually quiet, is melancholy, and has depression of spirits; although he has no fear of water, he does not drink; he makes no attempt to bite, and seems haggard and suspicious, avoiding society and refusing food. The breathing is labored, and the bark is harsh, rough, and altered in tone; the mouth is open from the dropping of the jaw; the tongue protrudes, and the saliva is

[1] Youatt, On Canine Madness.

constantly flowing. The breathing soon becomes more difficult and laborious; there are tremors and vomiting and convulsions."

Virchow[1] denies the existence of two distinct forms; he considers these to be merely prolonged states of certain stages of the disease—viz., that the sullen form is the first or melancholic stage, and that the furious is the second or stage of irritation. He describes the disease in dogs as consisting of three stages, and in the following manner: the first stage is the *melancholic*, and is often unnoticed and unrecognized at its onset; still there may be observed a palpable change in the natural condition, alterations of depression and exaltation, restlessness and change of place, sudden waking from sleep, irritability, deranged digestion, anorexia. The dog has often a greedy appetite, but sometimes leaves his food or snaps at it; there is natural thirst and no fear of water. After these premonitory symptoms have set in, the specific character soon becomes developed: there is great susceptibility in the cicatrix when a bite or wound has been the antecedent, a change of affection, character, and desires, a proneness to lap his own urine, and eat the feces of other dogs; a peculiar idiosyncrasy to take all sorts of unwholesome and indigestible things, such as straw, paper, wood, etc.; there is much sexual excitement, and eager licking of the genitals of other dogs; he seems friendly with the cat, but exhibits a marked change of affection towards his master; he becomes shy and backward, and avoids observation. The organs of deglutition and respiration become involved; there are spasms and difficulty in swallowing, as if something was sticking in the throat; alteration in the voice; arrest of salivary secretion; application of the tongue to cold surfaces, such as stone, iron, etc. Changes also take place in the motor system, for in all there is more or less debility and weakness.

The second stage is the irritable and *furious*. It commences generally in from one to three days, but may set in after twelve hours; it is seldom, however, met with after the eighth day. This irritation, the height of the disease, is not always uniform in its course; the paroxysms are strongest and longest at the onset, commencing with restlessness and irritability; he runs out of the house, attempts to bite, goes from place to place without thought or reason, endeavors to break his chain or destroy his kennel, and on his inability to do so increases in rage, and if he gets loose will run great distances. It is this proneness to bite which renders this period so dangerous. The paroxysms may last several hours and often even a whole day; then follows a remission which is very deceptive, as all the signs of disturbance subside, but the dog, aware of his unsociability, generally hides. The disease is very often described from dogs who have been hunted, hooted, and followed about in the streets and goaded on to madness; and in these severe symptoms are superadded, such as panting and flow of saliva, out-stretching of the tongue, thirst, dread of water, thrusting of the tail between the legs, starting of the hairs, etc. etc. The chief and prominent symptoms of this stage consist in psychical and æsthetic changes; there is a kind of acute mania and delirium, disobedience, no knowledge of his master, no avoidance of danger, sudden anger and snappishness, outbursts of wildness, loss of general sensation and all sexual feeling. The changes in respiration and deglutition are altered tone of voice, between barking and howling, indicative of extreme distress, swelling of the fauces, tongue, and nose. The movements of the body are rash and hasty, and the heart's impulse strong. The duration of this stage varies; it generally lasts three or four days, passing into the next and final stage; but in rare instances it may terminate suddenly in death, through a form of apoplexy.

The third stage is the *paralytic*. The paroxysms now become weaker and remittent, the animal emaciates rapidly, the coat falls off, the flanks sink in, the hind extremities are weak and lame, he lies on one side in great prostration, but when roused is still snappish and bites; if able to walk, he totters and drags himself along; the eyes are sunken and dull, the mouth open and dry, the tongue hanging out and hard, the heart's action weak, irregular, and intermittent, the breathing oppressed; convulsions may occur. Death takes place from exhaustion, or during a paroxysm, in from five to eight days from the first attack.

The disease has been noticed in the cat,[1] horse,[2] wolf, and other animals; and these, when so attacked, are capable of communicating the disease to man.

[Two recent cases in which hydrophobia followed the bite of a cat are recorded, one by Dr. Ira B. Read, of New York,

[1] Virchow, Handbuch der Pathologie u. Therapie, Band ii., Abth. i., p. 344.

[1] See, in the Transactions of the Medical Society of London, the case of a young lady who died in seventy-four hours from hydrophobia caused by the bite of a rabid domestic cat.

[2] Youatt, On the Horse. He describes this disease in the horse with his usual accuracy, and cautions the attendants on the communicability of the disease, as instances of death have resulted therefrom owing to carelessness.

in the American Journal of the Medical Sciences, for October, 1875, p. 567; and another by Dr. B. A. Watson, of Jersey City, in the same Journal, for April, 1877, p. 413.

In the same Journal, for October, 1875, Dr. J. A. Wolfe records a fatal case in which the bite was inflicted by a skunk (Mephitis Americana).]

We will now describe the symptoms of the disease in man, and we shall find some of them analogous to those of the dog, and some differing in several points. Thus, in man, there is excessive hyperæsthesia, frightful convulsions, and fear of water; also greater difficulty in swallowing, owing probably to the more difficult mechanical conditions of the act in man.

After the bite from a rabid animal, there is generally an absence of all immediate symptoms, so that the patient is thrown entirely off his guard and takes no further notice of the matter; the wound heals, and he pursues his ordinary avocation; but usually in the course of about six or seven weeks the first intimation of the disease shows itself. This period of latency varies considerably, according to certain conditions which will presently be referred to.

The premonitory symptoms which usher in the complaint comprise general and special manifestations: these constitute the melancholic stage of Virchow. The general symptoms are those commonly met with in other diseases, consisting of ordinary pyrexia, a feeling of being unwell, uneasiness and restlessness, loss of appetite, alternate chills and flushes, sore throat, and stiffness about the neck, often attributed to cold; then actual febrile symptoms set in, with nausea, vomiting, headache, and excitement. But soon, or even without any of the above symptoms, the peculiar and special characters become manifest, which generally last two or more days, and then speedily run on to the second stage. There is an irritation in the cicatrix of the bite, an itching and painful sensation, often regarded as neuralgic; this increases, and sometimes extends along the course of the nerve. The cicatrix often becomes red, swollen, and inflamed, and often ulcerates, discharging a thin unhealthy pus.

The condition of the cicatrix in ninety-five cases was accurately investigated: in sixty-six instances it had a normal appearance; five times no sensation whatever was noted; once it was extremely sensitive to pressure; seven times it was inflamed; nine times it presented a reddish or blue tint, but was painless; once it was very dark, etc. In all but four cases the surrounding parts were apparently healthy.[1]

[1] Cooper's Dictionary, last edition, vol. i., p. 1056.

The accompanying pain often takes on the character of chronic rheumatism, and shoots upwards towards the præcordia. The psychical and æsthetic changes consist in altered actions and affections; the patients become quieter; if children, they are more shy; if older people, they are depressed, lonely, and anxious, with a certain degree of listlessness, passing into a vacant stare, regardless of surrounding objects, a kind of melancholy; there is anxiety respecting the bite, making much inquiry and anticipating danger. Many, however, are unusually irritable and ill-tempered. There ensues a characteristic anxiety, attended with pain in the præcordia and sense of weight and pressure upon the chest; there is disturbed and broken sleep, the patient suddenly starting up in frightful dreams; often sinking back into mental depression, and becoming apprehensive and gloomy. The generative organs are sometimes excited, inducing priapism and seminal ejections. There is loss of appetite and no desire for swallowing; a feeling of clamminess; sighing and oppression of breathing, with unusually deep inspirations; the voice is rough. There is a sense of languor and lassitude, great weakness and heaviness; sometimes slight convulsive twitchings about the face and extremities: the heart's action is strong.

The duration of the premonitory symptoms of 119 cases was:—[1]

In	8	cases	only	a few	hours.
"	4	"	. . .	6	"
"	12	"	. . .	12	"
"	1	"	. . .	18	"
"	28	"	. . .	24	"
"	1	"	. . .	30	"
"	8	"	. . .	36	"
"	21	"	. . .	48	"
"	10	"	. . .	3	days.
"	1	"	. . .	3½	"
"	9	"	. . .	4	"
"	4	"	. . .	several	days
"	2	"	. . .	5	days.
"	2	"	. . .	6	"
"	2	"	. . .	7	"
"	2	"	. . .	8	"
"	3	"	. . .	12	"
"	1	"	. . .	several	weeks.

The second or actually specific stage is that of irritation; hydrophobia being its chief character. It generally follows after the premonitory stage, but in some cases it may become developed at once, so rapidly and suddenly as to take place without any preliminary manifestation. It is ushered in with stiffness of the muscles of the throat, jaw, and root of the tongue, pains in the epigastrium and dia-

[1] Thamhayn's Statistics; Schmidt's Jahrbuch, 1859, p. 101.

phragm, chilliness, and drowsiness. Next there is hyperæsthesia of the eighth pair of cerebral nerves, as evinced by the convulsive spasms of the muscles of deglutition, rendering all attempts at swallowing difficult, and causing severe paroxysms;[1] hence the great dread of solids and fluids, and the subsequent dryness of the mouth and throat with distressing burning thirst, which cannot be quenched. The spasm extends to the muscles of the larynx, inducing hurried respiration, and a sense of suffocation; the voice is changed and hoarse; the secretions of the mouth and fauces, which were at first frothy, become now viscid, and can only be expelled with difficulty, causing a hawking and barking noise in the effort. The convulsive spasms afterwards involve the muscles of the general system through the spinal and cerebral nerves, inducing convulsions which may resemble epilepsy and tetanus; and may last from ten to twenty minutes. There is flatulency, and vomiting of a dark-greenish bilious fluid; the micturition is frequent, and in later stages the urine is passed involuntarily. The senses are rendered morbidly acute, the surface of the body irritable, and readily acted upon by the slightest gust of air, or even the feeling of the pulse, as inducing an accession of the convulsive paroxysm; the sight or sound of fluids cannot be borne, as aggravating the attacks; sometimes even the smell of particular things will do so. The mind becomes in a state of frightful agitation, anxiety, and alarm; there is a fear of even their best friends and of being left alone; there is no comfort or consolation, but indescribable despair, with sometimes entire loss of control, exciting rage. There is no sleep, and the patient is often talkative and verbose. The mental disturbance may be very slight, but, on the other hand, attended with temporary rabid impulses and delusions, sometimes causing an inclination to bite. The features possess a wild sparkling appearance; the brows contracted, the eyes staring, the angles of the mouth retracted, and an intensely anxious and haggard aspect. As the disease progresses, the paroxysms increase both in frequency and violence, and are oftentimes attended with great cerebral excitement, bordering upon wild maniacal fury. The duration of this stage may last from twenty-four to forty-eight hours; it is generally short and severe.

The third or paralytic stage is the decline and last moments of the disease; it is attended with rapid depression and nervous exhaustion, intermission of the paroxysms, incoherency, and delirium; there is great emaciation; the mouth remains open, and the saliva runs out, or else passes back into the throat, causing a gurgling noise, and the urgent attempt to swallow it or spit it out induces a choking sensation. The pulse becomes small, quick, and irregular; the skin bedewed with clammy sweat; the eyes dull and sunken, and the pupils large; and death takes place either from asphyxia, during one of the convulsive attacks, or from exhaustion. The patient, however, may die quietly, sinking into a state of repose, with abatement of all the symptoms; in one case[1] being able to eat and drink, and expiring immediately on suddenly sinking.

The duration of the disease throughout its whole course varies from seventy-four hours to six or seven days; death generally occurs on the second, third, or fourth day; it has been fatal in sixteen hours, and examples have been recorded where it lasted two or three weeks.

Thamhayn (op. cit.) gives 202 cases, where the course and duration of the disease have been recorded, reckoning the period from the first paroxysm:—

4	cases in	. . .	12 hours.
2	"	. . .	14 "
1	"	. . .	15 "
1	"	. . .	20 "
19	"	. . .	24 "
7	"	. . .	30 "
14	'	. . .	36 "

[1] Dr. Marcet gives the following graphic description of hydrophobia, which may be taken as the standard, although not constant, condition: "On our proposing to him to drink, he started up and recovered his breath by a deep convulsive inspiration; yet he expressed much regret that he could not drink, as he conceived it would give him great relief, his mouth being extremely parched and clammy. On being urged to try, however, he took up a cup of water in one hand and a teaspoon in the other. The thought of drinking out of the cup seemed to him intolerable; but he seemed determined to drink with the spoon. With an expression of terror, yet with great resolution, he filled the spoon and proceeded to carry it to the lips; but before it reached his mouth his courage forsook him, and he was forced to desist. He repeatedly renewed the attempt, but with no more success. His arm became rigid and immovable whenever he tried to raise it towards his mouth, and he struggled in vain against the spasmodic resistance. At last, shutting his eyes, and with a kind of convulsive effort, he suddenly threw into his mouth a few drops of the fluid, which he actually swallowed; but at the same instant he jumped up from his chair and flew to the end of the room, panting for breath and in a state of indescribable terror."—Med.-Chir. Trans., vol. i., p. 158.

[1] Lond. Med. Rep., vol. xviii., p. 226; case quoted by Mr. Dendy.

4	cases in	.	.	.	40 hours.
4	"	.	.	.	42 "
73	"	.	.	.	48 "
9	"	.	.	.	60 "
29	"	.	.	.	72 "
2	"	.	.	.	84 "
17	"	.	.	.	4 days.
7	"	.	.	.	5 "
5	"	.	.	.	6 "
4	"	.	.	.	7 "

As regards the diagnosis, there is no one particular symptom which can be relied upon as forming a distinguishing mark of this disease; the symptoms must be taken collectively, and then there is no disease simulating it; thus, the peculiar combination of disturbance of the muscles of the pharynx and larynx, the psychical hyperæsthesia and fear, the altered voice, the difficult breathing and swallowing, the perverted appetite, the hallucination, and the easily excited rage, are for the most part the diagnostic signs. The dread of water, the almost characteristic symptom in man, is not always present, as may be proved in recorded cases. On the other hand, this symptom may be met with in other diseases: thus, in hysteria[1] we may have what is called hysterical hydrophobia, where the sight of water induces a paroxysm of hysteria, but this only lasts a short time; in inflammatory affections about the throat, larynx, and neck, and in certain diseases of the brain, there may be a difficulty and dread in swallowing fluids, which is called symptomatic hydrophobia; in hypochondriasis and melancholia there is sometimes painful and convulsive deglutition. The mental distress so characteristic of hydrophobia may also be observed in severe forms of hysteria, associated with high nervous excitement; Dr. Copland cites three instances in his article on Rabies in the Dictionary of Medicine. It resembles tetanus in many of its symptoms, as well as in its rapid progress and fatal termination; also in its most frequent cause, a wound or puncture of the surface of the body; but the distinction between the two is well marked, and has been adverted to in treating of TETANUS.

Post-mortem appearances.—As in tetanus, there is no distinct lesion to be found, otherwise than the ordinary appearances met with in persons dying from asphyxia and exhaustion. In general there is early stiffness of the body and early decomposition. The brain and membranes are congested, and occasionally there is serous effusion; but no abnormal changes are detected. The medulla oblongata, spinal cord, and its membranes present no visible lesions otherwise than congestion. In a case which recently occurred at Guy's Hospital, the medulla and spinal cord were carefully examined. Their sections showed extreme congestion of the gray matter, both of the anterior and posterior cornua, especially in the cervical and dorsal regions. In different sections, numerous minute patches of extravasated blood were found in every one; the vessels were noticed to be most unusually distended and full of blood.[1] Dr. Copland, however, remarks, "that the absence of all lesion in these parts has not been satisfactorily shown; and whether the existing lesion be one of an inflammatory character, or one interesting the intimate structure of these parts in such a manner as to escape the detection of our unassisted senses, there are strong reasons for inferring that some change actually exists in these situations, though it may not be limited to them, but may extend to the related and associated nerves, and even to the parts supplied from these sources and by these nerves.[2]

The nerves at the seat of injury or bite have been found inflamed, but not always so, and sometimes presenting a peculiar redness. The eighth pair of cerebral nerves and the cervical sympathetic have been said to be pinkish.

[1] Dr. Mason Good relates the case of a young lady of nineteen years of age, of a highly nervous temperament, who had hydrophobia or "water-dread" which had no connection with rabies, and was preceded by a very severe toothache and catarrh. The muscles of the throat had no constriction except on the approach of liquids, and the patient through the whole disease, which lasted a week, was able to swallow solids without difficulty; but the moment any kind of liquid was brought to her, a strong spastic action took place, and all the muscles about the throat were violently convulsed if she attempted to swallow.—Op. infr. cit., p. 273.

[A fatal case in which hydrophobia was a most marked symptom, and yet of which it is said that the patient was certainly not bitten by a dog, or other animal, was narrated by M. Guillery to the Belgian Academy of Medicine in 1871. The patient was a tailor, seventy-one years old. The dread of water was intense, not only when the attempt was made to swallow it; but the mere sight of it, or its use for ablution, was sufficient to bring on most violent spasms. Death ensued in three days. See American Journal of the Medical Sciences, April, 1872, p. 529; from Bulletin of Belgian Academy, No. 8, 1871. See also an interesting case of nervous hydrophobia recorded by Féreol, in American Journal of the Medical Sciences, October, 1874, p. 547, from L'Union Médicale, July 30, 1874.]

[1] Forster, Guy's Hosp. Rep., series iii., vol. xii., p. 12. Case 5, boy, æt. 13.

[2] See article Rabies in Copland's Dictionary of Medicine.

The fauces, pharynx, and œsophagus are found reddened and injected, from vascular excitement; sometimes coated with lymph; but in other instances no change whatever existed.

The salivary glands are sometimes normal, and at other times enlarged and vascular.

The larynx, trachea, and lungs have their lining membrane injected and congested; and there is a viscid frothy mucus in the tubes.

The heart and pericardium are either normal, or present evidences of death from asphyxia.

The blood is black and fluid, infiltrating the tissues, and sometimes grumous: Ragsky has analyzed it, and found in 1000 parts—769.6 water, 4.8 fibrin, 133.0 blood-corpuscles, 80.2 albumen, 12.4 extractive matter and salts.

[*Pathology in the dog.*—In the Medical Times and Gazette for July 29, 1876, are described the following microscopical changes in the sympathetic and spinal ganglia, found by Dr. Kobsnikoff, of St. Petersburgh, in ten dogs examined by him. 1. Extreme dilatation of the blood-vessels, which were blocked by red corpuscles. Some of the latter had escaped from the vessels and were scattered with white corpuscles in the peri-vascular spaces. In some places hyaloid masses of various shapes projected into the lumen of the vessels, which sometimes were entirely obstructed thereby. These masses seemed to result from a metamorphosis of the white and red corpuscles. 2. Around the nerve-cells were collections of round-cell elements, some of which had projected into the nerve-cells, so as to give the latter a jagged outline. Sometimes the nucleus was forced outwards, by the impinging of the new cells, to the edge of the nerve-cell, and sometimes the new cell-elements seemed to take the place of nerve-cells which had disappeared. These observations originally appeared in the Centralblatt, for November 29, 1875.

Pathology in man.—In a paper read before the Royal Medical and Chirurgical Society, in 1877, Dr. Joseph Coats affirms that there is an accumulation of leucocytes (corpuscles) around the bloodvessels of the central nervous system. The medium-sized vessels of the cord, medulla oblongata, pons, and corpora quadrigemina are the ones principally affected, while in the convolutions of the cerebrum it is the smaller and capillary ones around which these changes are found to have taken place. Leucocytes having special relations to the bloodvessels infiltrate the salivary glands, while a similar condition of things in a lesser degree, obtains in the mucous glands of the larynx. The kidneys are hyperæmic, and contain very many white corpuscles. Dr. Coats thinks that the local symptoms are attributable to the lesions in the medulla, and especially in the neighborhood of the nuclei in the floor of the fourth ventricle.[1]]

Pathology and nature of the disease and its causes.—Much discrepancy of opinion exists as to the seat and nature of the disease, inasmuch as the absence of physical changes gives rise to numerous speculations.

There is a great analogy to the more virulent poisoned wounds, such as the poison of venomous serpents, the severe form of dissecting-wounds, and the acute form of glanders; but each of these forms has its peculiar action and appropriate symptoms. So, again, vegetable and mineral poisons have their special action; thus, alcohol affects the brain, strychnia the medulla oblongata, etc. Hydrophobia or rabies is considered by many to be a peculiar and specific poison, a kind of ferment, acting on the nervous system, and inducing hyperæsthesia of the medulla oblongata and neighboring nerves.

Dr. Copland remarks, that "the history, progress, and character of this affection are essentially that of a nervous malady of the most intense form, involving the medulla oblongata and pneumogastric nerves: it is not imbibed by the capillaries and carried into the circulation, as evinced by its latent protracted period; it is not absorbed by the lymphatics, as there is absence of all glandular irritation."

Mangor describes the disease to be a continued fever; Rust and many others consider it to be an inflammatory affection. Some believe the sanguiferous system to be the seat of disturbance, but whether this disturbance is produced by changes in the blood has not been proved.

Some, again, consider the disease as being only symptomatic, and that the true disease is of another kind: thus Rychner ascribed the sullen rabies to a urinary affection; Prinz and Heusinger to a form of carbuncle.

Some regard it as a form of tetanus, and deny its contagious character; but neither of these opinions has any support.

Sir Isaac Pennington and others have actually denied its existence, and attribute the symptoms and effects to imagination.

Dr. Marochetti, in 1820, observed the formation of vesicles or pustules under the tongue: and this observation was confirmed in 1822 by M. Magistel in France. Two species of pustules are described, the crystalline and the opaque: the former

[1] [*Vide* the Lancet for December 15, 1877, and the American Journal of the Medical Sciences for April, 1878, p. 533.]

projecting, rounded, and of the size of hempseed, transparent, and containing a limpid serous fluid; the latter, flattened, of a circular form, of the size of a lentil, and without transparency. The crystalline appear early in the latent stage, and not in all the persons who are bitten; the opaque are observed at a more advanced period, and all persons bitten exhibit them.

The primary and essentially exciting cause of the disease is a peculiar poison generated or contained in the saliva or secretion from the mouth of the rabid animal, conveyed by the teeth or lips, and so inoculating the individual. It is not requisite that there should be an actual bite, but there must be an abraded surface. Trolliet[1] maintained that the poisonous agent is not the saliva *per se*, but the frothy matter driven out from the bronchi and mixed with the saliva. From experiments it is proved that neither the blood, flesh, milk, seminal fluid, nor the breath, nor the secretions and excretions of the abdominal viscera, are capable of producing hydrophobia, although Majendie has endeavored to prove that the blood is contagious.

Respecting the nature of the poison, Dr. Copland asks, "Does it consist in a material, organized, or chemical change in the secretion constituting the virus; or is the secretion merely the vehicle of a nervous aura or emanation which is actually the infecting agent, and which is retained in its vehicle for only a short period?" The first of these opinions is the one generally adopted.

As regards the activity of the poison, it is more volatile and less active than many other morbid poisons; hence all that are bitten do not suffer; thus, Hunter gives an instance in which, out of twenty persons bitten by the same dog, only one received the disease. Faber states that at Wurtemburg, of 145 persons bitten, 28 only were attacked. It is generally calculated that of those who are exposed to the venom about one in four matures the complaint, and the rest escape.

This virus is capable of propagation from the human subject to any animal by inoculation, but there is no example of transmission of the poison from man to man. MM. Majendie and Breschet collected upon a piece of linen a portion of the saliva of a rabid man in the last stage of the disease, and inserted it under the skin of two healthy dogs, one of which became rabid and bit two other dogs; of these latter one also fell a victim to the disease just a month afterwards.

The period of incubation or latency is generally long, seldom less than 40 days; however, the disease may occur as early as the 7th or 8th day; and again, it may not manifest itself until the 7th or 9th month; in some rare instances it has been stated to have been developed as long as 12 years after the bite.

Trolliet gives the following summary of 23 persons who were bitten by a mad wolf in the space of 9 hours, and of whom 13 died; of these latter, in 6 the disease appeared between the 15th and 30th day, in 4 between the 30th and 40th day, in 2 between the 40th and 53d day, and in 1 in three months and 18 days.

Thamhayn (op. cit.) records the period of incubation in 220 instances:—

2	in	3 days.
2	"	4 "
2	"	9 "
3	"	10 "
1	"	11 "
1	"	12 "
1	"	15 "
2	"	17 "
2	"	18 "
4	"	19 "
4	"	20 "
9	"	21 "
16	in course of	4 weeks.
27	"	5 "
37	"	6 "
16	"	7 "
8	"	8 "
11	"	9 "
7	"	10 "
5	"	11 "
6	"	12 "
12	"	13 "
3	"	14 "
4	"	15 "
7	"	16 "
6	in course of	5 months.
4	"	6 "
3	"	7 "
1	"	8 "
1	"	9 "
2	"	10 "
1	"	11 "
3	"	12 "
1	"	15 "
2	"	18 "
1	"	24 "
1	"	26 "
1	after	4 years.
1	"	5½ "

The predisposing causes require but little comment. Every sex and age, without discrimination, are liable to its attack; even the infant at the breast has been the subject of hydrophobia. Respecting the constitution and habits, there is no temperament, no strength nor weakness of body, proof against the disease; no mode of life or class of society makes any difference; it invades alike the rich and the

[1] Traité de la Rage.

poor, the well-fed, without anxiety or trouble, and the poverty-stricken and hard-working person.

Of its frequency in particular countries or its geographical distribution, the popular notion is, that great heat and cold induce the disease; but this is fallacious; for those most exempt are the inhabitants of Greenland, Kamtschatka, Sweden, and Denmark; and this is asserted to be the case also with the inhabitants of the tropics, the south coast of Europe along the Mediterranean, the whole of Africa, South Asia, and America. However, this latter assertion is not actually correct; for although it was stated by Alpinus, Larrey, and others, to be unknown in Egypt, yet Pruner, in 1847, found not only the disease, but that it was well known to the Koptic tribes; Guyon found it in Algiers, Johnson in the East Indies, Rust in North America, and many others have observed it in the West Indies, South America, Mexico, etc. Dr. Morehead found it in Bombay to bear the same ratio to population as in England, and to be equally fatal.

It appears to prevail, not so much in relation to the climate as to the presence of animals capable of generating the disease, and thereby transmitting it to man. Thus, in former years in Prussia, when there were numerous wolves infesting the forests, the disease was very prevalent, for from 1810 to 1819 inclusive there were 1635 deaths. And again, the accounts seem to refer the disease rather to transmission than to spontaneous development; thus, Mosely states that before 1783 it was not known in all the West India Islands for fifty years, when in the spring of that year it broke out at Hispaniola, and in June at Jamaica, and remained until March, 1784, and that it was stated to have been imported into Jamaica. In the Mauritius it was unknown until 1821, when it was introduced by an English ship from Bengal, and it became developed to a great extent. In the great epizootic of 1852 in Northern Germany, in Hamburg alone there were 267 mad dogs, whilst at Elbisland, during the same period, there were no instances. It is stated to be rare in England, and Dr. Willan remarks that in his time only one instance occurred during five years in London. At Edinburgh, in 1824, not a single case had occurred during twenty-five years. The mortality from this disease in England, as stated by the Registrar-General's returns, was, during the ten years from 1847 to 1856, 128 cases, of which 101 were males, and 27 females.

The disease occurs pretty uniformly through every season of the year and every range of temperature; it has appeared under every variety of meteorological changes, and the association of dog-madness with the dog-star is incorrect. Faber, in his statistics, at Würtemberg, found it most frequent in the months of March, February, June, and January, and least prevalent in September, October, and August. Trolliet, however, from his statistics, shows that most cases occur in February, May, July, September, and October.

M. Saint-Cyr[1] has written an elaborate pamphlet on the influence of the temperature and moisture in the development of "La Rage," and gives tables of his observations. He says: "We have not been able to discover any satisfactory relations between the thermometric and hygrometric conditions of the air and the frequency of the disease; nothing even resembling the shadow of a law. We have, however, no right to conclude that these conditions are absolutely without any influence on the development of the affection."

The excitement of vehement rage has been looked upon as a predisposing cause, inasmuch as most animals, when roused to a high degree of rage, inflict a wound of a much more irritable kind. It has been thought that rage has a peculiar influence on the salivary glands, and excites the secretion of an acrimonious virus; but the symptoms induced thereby are not those of hydrophobia, although of a highly nervous character.

The eating of putrid food cannot be regarded as a cause, for this is the ordinary state in which dogs and cats obtain the offal, to which they show no disgust.

Long-continued thirst, from want of water to quench it, has been suggested as a cause; but in long voyages, when reduced to short provisions, dogs have died of thirst and hunger without any signs of hydrophobia. Experiments have been instituted respecting this point: one dog was fed with salted meats and totally restrained from drinking, a second was allowed nothing but water, and a third neither meat nor water; the first died on the forty-first day, the second on the thirty-third day, and the third on the twenty-fifth day, not one of them evincing the slightest symptom of the disease.

The treatment will comprise, first, the immediate, or that employed at the time of the bite, which may be termed the preventive or prophylactic. This is to be managed in the same way as is adopted in all other poisoned wounds—viz., by immediately destroying the injured part by powerful escharotics, which are to be unsparingly used to the whole surface and entire depth of the bite. Mr. Youatt states that he has employed

[1] Gaz. Méd. de Lyon, March 29, 1868.

lunar caustic to upwards of 400 persons, and four times on himself, after bites from dogs decidedly rabid, and he has not seen the disease appear in one instance. Any of the escharotics are serviceable; some prefer the caustic alkalies, others nitric acid, sulphuric acid, arsenical paste, chloride of zinc, actual cautery, boiling oil, etc.

Complete excision, and even amputation of the part, has been had recourse to, and with success; but excision is preferable, and is often performed on the spot, at the moment of the infliction of the bite, in the absence of escharotics. Ligature around the part above the bite is only serviceable for a time, while the proper means of treatment are being procured.

During the stage of incubation, or the latent period, where the bite has been allowed to pass by unnoticed, and where the patient commences to feel anxious about it, seeking advice, then we must still adopt the same measures as above, and endeavor to destroy the latent poison, which by many authorities is considered still to reside in the situation of the bite, by resorting to excision. It is also recommended to ascertain if there be any vesicles or pustules under the tongue, as affirmed by Marochetti; and if present, these are to be opened and cauterized. We must adopt, at the same time, a psychical treatment, by holding out the greatest hopes to the patient, and dwelling on the probable prospect of cure, and never allowing any depression of mind. Stimulants and antispasmodics may be given, as also anodynes and narcotics; tonics are often required, and the usual diet may be allowed.

When the distinctive characters of hydrophobia make their appearance, and during the progress of the disease, curative attempts must be made. Many specific medicines have been used and extolled, comprising articles from the mineral, vegetable, and animal kingdoms, but all these so-called antidotes have signally failed. The whole list of remedies alluded to in the treatment of tetanus has been had recourse to and with little effect; among the most prominent are the following: full and profuse venesection, but this has generally caused a more rapidly fatal issue; the free use of mercury, both internally and externally, to produce salivation, is neither specific nor beneficial, although a case of cure is reported in the American Journal of the Medical Sciences, vol. xxxix., p. 96, from drachm-doses of calomel; diuretics, drastic purgatives, and emetics are likewise of little benefit; the injection into the veins of warm water, as recommended by Majendie, or of solutions of opium and morphia, as suggested by Dupuytren, have failed.

The following are the general principles upon which we ought to act in our treatment of this disease; first, to allay the highly nervous and spasmodic affections by quieting the excited psychical and physical conditions; by the cautious administration of sedatives, opiates, and antispasmodics—such as opium, morphia, belladonna, musk, chloroform, cannabis indica, etc.; by absolute rest, quiet companions, kindness and gentleness in speaking; by giving hopes; by the avoidance of all noise and draughts; by maintaining an equal temperature. Secondly, to support the vital powers by tonics, nutrition and stimulants, so as to enable nature to combat with the disease. Thirdly, to alleviate urgent symptoms, such as thirst, by the use of ice, etc.; and to relieve obstructed respiration and impending suffocation from laryngeal spasms, by laryngotomy or tracheotomy.

Dr. Good writes: "It is highly probable that a spontaneous cure may be occasionally effected by the strength of the constitution or the remedial power of nature alone. The fact appears to be, that the disease requires about six or seven days to run through its course, at the expiration of which period the system seems to be exonerated, by the outlet of the salivary glands, of the poison with which it is infected. And hence, if by any means it be able to sustain and carry itself through this period, without being totally exhausted of nervous power in the course of so protracted and prostrating a conflict, it will obtain a triumph over the disease; and any prescribed medicine made use of on the occasion will seem to have effected the cure, and will run away with the credit of having done so, till subsequent instances dissolve the charm and prove beyond contradiction the utter futility of its pretensions. Our grand object must be to keep the patient alive, and prevent a fatal torpitude in the sensorium for a certain number of days, at any expense of stimulants or of subsequent debility. Wine is profusely given with great success in the bites of the most venomous serpents of the East, and analogy justifies us in proposing it in the present instance."[1]

[The many new remedies of late years have had among them several which have been recommended for, and tried in cases of hydrophobia, and in a few instances these trials have been followed by recovery. So strong, however, is the conviction of the necessary fatality of this disease, that the profession is very much inclined to call in question the accuracy of diagnosis in those cases where a recovery has ensued. Yet there would seem

[1] Good's Study of Medicine, vol. iii., p. 303.

to be no reasonable ground to doubt that a few veritable cases have occurred in which rational treatment has produced a cure.

Chloroform inhalation has often been followed by amelioration of the symptoms, but without affecting the result. So it has been with its congener chloral, taken internally. Intravenous injections of a watery solution of the latter were resorted to by M. Bucquoy, but with only temporary benefit, *vide* Gazette Hebdom., 17th July, 1874. Similar treatment, with a like result was adopted by Prevost and Toloz, Gazette Médicale de Paris, No. 26, 1876. Inhalations of ether have been frequently resorted to. The combined use of bromide of potassium, chloral, and hypodermic injections of morphia and atropia accomplished nothing when resorted to by Wolfe, American Journal of the Medical Sciences, October, 1875, p. 567. Woorara has been resorted to in several cases. Watson combined it with strychnia, and recovery ensued in a well-marked case with an apparently unquestionable history, American Journal of the Medical Sciences, July, 1876, p. 81. In the same journal for January, 1877, at page 136, will be found the history of a case in which Dr. Ira B Read combined woorara with morphia with amelioration of the symptoms, but without averting a fatal issue.

Woorara is credited with having been successfully resorted to by Offenberg of Berlin, see Medical Record, March 18, 1876.

The inhalation of the nitrite of amyl has been tried with very great relief to the symptoms, but without preventing a fatal termination. Dr. W. S. Forbes, of Philadelphia, who reports two cases in the American Journal of the Medical Sciences for April, 1878, page 402, thinks that the improvement which followed the use of this agent was so marked as to give good grounds for encouragement in its further use.]

Glanders.

Glanders is a disease peculiarly appertaining to the horse, consisting of a specific poison, which is highly contagious and capable of being communicated to the human species through the medium of inoculation. Although this disease has been recognized in the horse from the time of Hippocrates, yet it is only of late years that it has been satisfactorily proved to exist in man. It was formerly entirely overlooked, and the disease considered to be one of a purely local character attendant upon unhealthy and unclean wounds, terminating fatally. Dr. Elliotson was the first who accurately described the disease in man, and he termed it Equinia, as proceeding from the horse. Glanders essentially consists in an eruption of peculiar tubercles or deposits which manifest themselves under two distinct forms, which are, however, merely different types of one and the same disease. Thus in the one form it attacks the mucous membrane of the nose and neighboring glands, and constitutes what is termed glanders proper; this is the *morve* of the French, and *Rotz* of the Germans. In the other form it affects the absorbents or lymphatics and the skin, either of the extremities or trunk, causing enlargement of those parts, and producing a corded and knotty condition under the skin, not unlike worms; hence the term applied to this form by the Germans, viz., the *Wurm or Hautwurm*. It is known in England by the name of farcy or farcy buds, and in France by that of *farcin*. The disease generally appears in from three to six days after inoculation, although some affirm that it may not be developed for weeks or months after.

The symptoms of glanders in the horse are thus described by Youatt:[1] The local symptoms are, a nasal discharge, which is the earliest sign, and consists of an increased secretion, small in quantity and flowing constantly, and is of an aqueous character, mixed with a little mucus. It is not sticky when first recognized, but becomes so afterwards, having a peculiar viscidity and glueyness. The discharge soon increases in quantity, and becomes discolored, bloody, and offensive in the advanced stages. On the other hand, the discharge may continue for many months, or even for two or three years, unattended by any other symptom, and yet the horse be decidedly glandered. The glands under the jaw soon become enlarged, and are generally observed on the same side as the affected nostril; the swelling at first may be somewhat large and diffused, but this subsides in a great measure, and leaves one or two glandular enlargements, which become closely adherent to the jaw-bone. The mucous membrane of the nose becomes of a dark purplish hue or almost of a leaden color; never the faint pink blush of health or the intense and vivid red of usual inflammation. Spots of ulceration will probably appear on the membrane covering the cartilage of the nose: these ulcers are of a circular form, deep, and with abrupt and prominent edges, and become larger and more numerous, obstructing the nasal passages and causing a grating or choking noise in breathing. The disease extends upwards into the frontal sinuses, and the integument of the forehead becomes thickened and swollen, causing peculiar tenderness. The absorbents about the face and neck become now implicated, constituting

[1] Youatt, On the Horse.

farcy; these enlarge and soon ulcerate. The absorbents on the inside of the thigh, and then the deep absorbents of both hind legs, are next involved, causing them to swell to a great size, and become stiff, hot, and tender. The constitutional symptoms are, loss of flesh, impaired appetite, failing strength, more or less urgent cough; the belly tucked up; the coat unthrifty and readily coming off. The animal soon presents one mass of putrefaction, and dies exhausted.

Respecting farcy, Youatt describes it in the horse as being a different type of the same disease: "It is an affection of the absorbents and their glands, usually attacking the extremities, commencing in a kind of glanderous chancre or ulcer. The absorbents open upon every chancre, and take up a portion of the virus, which is secreted by the ulcer, and as it passes along the absorbent vessels, these suffer from its acrimonious quality; hence the *corded veins*, as they are called by the farrier, or more properly the thickened and inflamed absorbents following the course of the veins. At certain distances in the course of the absorbents are valves, and these belly out and impede or arrest the progress of the matter towards the chest. The virus at these places causes swellings, which are very hard, even of a scirrhous hardness, more or less tender, and with perceptible heat about them. They are observed about the lips, nose, neck, axillary spaces, and thighs. Suppuration and ulceration next ensue. The ulcers are rounded, with elevated edges and pale surface; they are true chancres, and discharge a virus as infectious, as dangerous, as the matter of glanders. While they remain in their hard and prominent state, they are called *buttons* or *farcy buds*, and they are connected together by the inflamed and corded absorbents. The constitutional symptoms are, drooping, impaired appetite, loss of flesh; the coat will stare. The horse may then rally, and appear to be restored to health. By degrees, however, the affection soon becomes general; the myriads of capillary absorbents that penetrate every part become inflamed and enlarged, and cease to discharge their functions; hence arise the enlargements of the substance of various parts, swellings of the legs, chest, and head; these are sudden, painful, and enormous, distinguished by a heat and tenderness which do not accompany other enlargements."

In man the disease manifests itself in much the same form as in the horse, viz., as glanders or farcy; but in general these two forms are associated, commencing either as acute glanders followed by farcy, or as farcy rapidly succeeded by glanders; the disease is also more frequently attended with an extensive tubercular eruption of the skin of an exanthematous character. There is a stage of incubation of from two to fifteen days, and then the disease passes through a premonitory stage, consisting of ordinary pyrexia, febrile excitement, etc., and then through its specific or eruptive stage, with its special local and constitutional symptoms. The stage of invasion, or the premonitory stage, commences with a feeling of indisposition or depression, and with peculiar wandering pains, followed by febrile excitement, shivering, great heat, and uneasiness; soon after there is pain affecting the muscles simulating rheumatism, and often mistaken for it. The pain generally attacks the extremities, and more especially the bend of the groin, the axillæ, and neck; where, upon careful and minute examination, swellings may be detected, which are sometimes diffused and sometimes circumscribed, indicating glandular complication: these may disappear suddenly, or may be altogether absent. The fever soon assumes a more inflammatory character, the pulse becoming full, 92 to 96; the skin is hot and dry, the face flushed, and the head heavy; there is want of sleep, the tongue is foul, the urine scanty and high-colored. Rigors ensue, there is profuse perspiration of a sour character, and diarrhœa may set in.

Sooner or later the second stage, that of eruption, takes place, and at once develops the specific characters of the disease. In acute cases this almost at once appears soon after the invasion, but in chronic cases there may be an interval of weeks. The following are the local and constitutional symptoms of this stage. The most prominent is the glanders-eruption, consisting of a crop of pustules, remarkably hard, simulating those of smallpox, and attacking the skin like an exanthem; it is considered to be peculiar and specific of the disease. Rayer has regarded it as quite distinct from the pock-pustules of ecthyma and other exanthemata. Virchow states, that although in outward appearance these resemble pustules, they are not so in reality, as they consist of a firm and tenacious deposit in the corium of the skin, of a whitish or yellowish material, over which the epidermis passes. He describes their development as follows: "At first there appear some red spots, which are very small, and resemble flea-bites, and soon acquire a papular elevation, subsequently rising above the level of the surface like small shot, assuming a yellow color. These shot-like knots are either flat or round, and do not lie in a bladder-like elevation of the epidermis, but in a kind of hole in the corium, as if the latter had been punched out; they are not always solitary, but often disposed in groups. There is some surrounding injection, and under the epidermis there is found a puriform and yellow fluid, seemingly consistent, which is chiefly formed from softening of the knot. They are composed of a homogeneous yellowish substance, which

Plate VIII.

is pretty firm and somewhat brittle, and have great resemblance to tubercle. Microscopically examined, they present an amorphous granular appearance, mixed with cell-elements and cell-growths, and numerous fat-globules."[1] Virchow considers them to be a cell-formation in the first instance, which subsequently passes into a cheesy condition, and then softens down, producing the pus of glanders and the farcy abscesses. They attack in a similar manner the mucous membrane of the nose, where the knots are small and linseed-shaped, and give rise to the peculiar nasal discharge. Softening of these tubercles next ensues, the skin gives way, and ulceration follows; and thus there are left small holes filled with débris.

[Rindfleisch says that the deposits are entirely made up of embryonic tissue, and differ from the corresponding products of syphilis and leprosy in a speedier rate of change, terminating invariably in suppuration.[2]]

In all the cases of glanders which we have observed during the past five years, the eruption commenced as vesicles, and rapidly became pustular with an inflamed livid base; the pustules were scattered indiscriminately over the face, neck, and abdomen, and some few on the extremities; when closer together they became confluent, discharging a sero-purulent fluid, ultimately leaving an irregular ulcerated surface, encrusted with a soft brownish sloughy coating. When appearing about the face and neck they were accompanied with an erysipelatous redness of the skin, causing puffiness of the lids, cheek, and neck.

In the very early stage they were not at all unlike the eruption of varicella. The illustration opposite represents other eruptions on the face, neck, and chest in a man æt. twenty-three, who died on the thirteenth day.

These tubercles may be developed in other situations, such as in the subcutaneous cellular tissue, producing circumscribed, hard, and painful boils, or else diffused swellings of great extent, which either open spontaneously, or give rise to extensive sloughing of the skin and deeper structures; or, in rarer instances, subside and reappear in other parts. This form is termed flying farcy. Accompanying the eruption, we found sooner or later, generally at the same time, small soft tumors scattered about the extremities, forming a kind of pyæmic abscesses, generally seated in the muscles, seldom attacking the glands, and when subcutaneous remarkably defined, like an egg. This condition is represented in the second illustration, taken from a man æt. fifty, who died on the twelfth or thirteenth day.[1] They may likewise occur in the substance of the muscles, more especially in those of the calf of the leg and back, forming distinct, hard, isolated masses, which are often exceedingly painful; but these more often are not observed until after death, when they may be found varying from the size of a millet-seed to that of a walnut, and in various stages of softening.

In the more advanced stages of the disease these eruptive tubercles or pustules attack the mucous membrane of the larynx, trachea, and bronchi, as also the lungs and pleura, causing pneumonia and pleurisy. Virchow considers that the part where there is most exudation is in the lungs; and here there is, for the most part, a series of tubercles on the surface, covered by a fibrinous pleuritic layer, and exciting internally lobular hepatization, forming the pneumonia of glanders.

Occasionally the tubercles attack other organs, such as the testicle, infiltrating it, and simulating rheumatic orchitis; the kidneys; the pancreas; the serous and synovial membranes.

Some authors describe the eruption as consisting of phlyzacious pustules in livid patches and in small tumors which arise in different parts of the body; the pustules being round, and often umbilicated, containing a liquid purulent matter, with a little coagulated lymph in the form of a white soft substance, very similar to that contained in variolous pustules, and in the phlyzacious pustules induced by the external application of tartar emetic.

The mucous membrane of the nose, frontal sinuses, and parts adjoining, becomes involved, and the nasal discharge is one of the first symptoms of the disease, and may precede any visible eruption on the mucous membrane of the nose: at the onset it resembles more or less ordinary catarrh, and is thin and clear, like water; but afterwards, as in the horse, it becomes characterized by forming a thick, sticky, highly tenacious, puriform fluid, of a dirty yellow or red-brown color, often mixed with blood. Should the patient be in a recumbent position, this discharge may flow back through the posterior nares, and escape observation, so that the practitioner may overlook the disease. As far as our observation has gone (and this is confirmed by the recent reports of other cases), the nasal discharge did not exist or take place

[1] Handbuch der Pathologie und Therapie, Band ii., Abth. 1.

[2] Pathological Histology. Sydenham Society's translation, vol. i., p. 387.

[1] See the report of both these cases in Guy's Hosp. Reports, series iii., vol. vii., p. 304. Wax models 296[u], 296[ul].

until just before the death of the patient; indeed, in one well-marked case, there was no discharge, but merely a slight reddening of the mucous membrane.

The nose and face become œdematous and swollen, of a dusky and shining appearance, which extends to the eyes and scalp; the conjunctivæ may be covered with thick secretion, gluing the eyelids together.

The submaxillary glands are seldom involved in man; but the tonsils are peculiarly liable to be affected, and large abscesses are often formed in them.

The swellings and discharge increase, the latter becoming profuse and intense; inflammation extends; bullæ appear on the integuments, and abscesses form one after another; and gangrene sometimes attacks the nose, eyelids, etc.

The constitutional symptoms during the progress of the disease are severe, and at first of the inflammatory type, but soon assume a typhoid character: the pulse, 110 to 120; the skin hot, and covered with clammy sweat of a peculiar sour odor: there is excessive thirst; low delirium with tremors, and laborious respiration; coma supervenes, and death results from exhaustion. In many instances the symptoms resemble those of pyæmia.

The duration of the disease varies; in the acutest form it is fatal within a week, and death has taken place even within three days: in others it has lasted three or four weeks, and in some rare instances life has been prolonged for many months.

Such are the effects of acute glanders in man; but in many instances it is associated with acute farcy, which consists in the superaddition of inflamed absorbents and lymphatics, and is generally induced by the inoculation of a scratch or abrasion on the extremities; in these cases we have diffused suppuration of the limb, and suppurating glands.

The other modifications are the slow or chronic forms of the disease. The chronic glanders is remarkable for its slow development and course, and slow death; the discharge from the nose is fetid and viscid, attended with pain and swelling of that part as well as of the eyelids: abscesses form near the joints, and profuse perspiration and emaciation occur.

In the chronic farcy the wound degenerates into a foul ulcer, and the inflammation and suppuration of the lymphatics are slow and tedious, but it often terminates in acute glanders.

As an instance of the chronic form of the disease, the following case, quoted from Travers,[1] is appended. Nimrod Lambert, a healthy hackney coachman, æt. 32, infected a chap on the inside of the right thumb, by inserting it into the nostrils of a glandered horse to pull off a scab. He remembered to have afterwards wiped the thumb with a wisp of hay. In the space of six hours he was seized with violent pain and swelling of the thumb; it inflamed rapidly. On the third day he was suddenly taken ill, whilst driving, with cold shivers and giddiness, and stated that he entirely lost the use of his limbs for seven hours. At this time his arm pained him much all the way up, and on the following day it was streaked with red lines and excessively swollen. The armpit was also much swollen and tender. In the evening of the fourth day he was carried to Guy's Hospital, where he lay during twenty-four weeks. Superficial collections of matter formed successively in the course of the absorbents. The corresponding portion of the integuments sloughed, leaving extensive ulcers which discharged an unhealthy and fetid matter. The glands at either angle of the lower jaw and those of the groin became swollen, and he was much afflicted with pain between the eyes and down the nose, and ulceration of the membrana narium attended with discharge. During the progress of the local disease he had much constitutional illness. He totally lost his appetite, and was oppressed with nausea, complained of severe pains with swimming in the head, and occasionally wandered in mind. He had also much pain through the whole course of the spine, especially in the region of the kidneys. His urine was thick and discolored, and fetid; his motions were slimy and purulent. Expecting to die, he quitted the hospital, and lay at home the remainder of the twelvemonth in a state of great emaciation from the continued discharge of his sores, and his inability to take food or procure any refreshing sleep, even with the assistance of opiates, which he took habitually. At the end of the twelvemonth his health gradually returned, the arm began to heal, and he became comparatively hearty and resumed his occupation, though with much inconvenience, owing to the distortion of his hand by the retraction of the thumb and forefinger, in the cicatrization of a long line of abscesses, reaching to the middle of his upper arm. After six weeks this cicatrix ulcerated afresh, and healed slowly. He became subject to wandering pains in the head, both sides of the neck, loins, and groin; was not so strong or so fleshy as formerly, but had a good appetite. He had a great heaviness and disposition to sleep during the day; and at the end of two years and a half from the breaking out of the disease considered his constitution broken, and despaired of being ever again the man he was.

An ass was inoculated by Mr. Sewell with the matter of this man's sores, and died glandered.

With regard to the diagnosis of the disease in the horse, Mr. Youatt remarks, that it is chiefly recognized by the dis-

[1] On Constitutional Irritation, p. 362.

charge from the nostril and by a singular hardness of the glands in the proximity of the jaw-bone, which are frequently actually adherent to it; these glands being rarely large except at first, and neither hot nor tender; the adhesions are owing to inflammatory action and the effusion of lymph on the exterior. He says if there be a doubt, the inoculation of a condemned horse or ass with the nasal discharge will reproduce the disease in a few days.

In man it is most difficult to recognize at its onset, as the general symptoms do not differ from those of ordinary animal poisoning. In the early eruptive stage it is very much like the smallpox, and may have its shotty feel; but the history and subsequent development of the disease will soon indicate its nature; at a later period it resembles rheumatism, pyæmia, and typhus fever; but when once the eruptive stage is developed, all doubt will be at an end; the presence of a peculiar exanthem, the local nasal discharge, if present, the erysipelatous blush in the face and eyes, the tumors and knots in the cellular tissue and muscles, and the local suppurations, sufficiently attest its character. Billroth lays great stress on the numerous hæmorrhagic abscesses in the muscles as being very characteristic of the pyæmia of glanders.

Glanders is not to be confounded with an eruptive disease produced by the morbid fluids generated in the affection called *grease*, an inflammation and swelling in the heels of the horse, from which at a certain period a very acrid thin matter issues. This, when applied to any abrasion of the hands, gives rise to a pustular affection of the skin, and is termed *Equinia mitis*, in contradistinction to glanders, which is often called *Equinia glandulosa*. It is not at all uncommon among coachmen, stable-boys, farriers, and other persons who dress the heels of horses affected by the disease. The pustules are very similar to those of ecthyma, are elevated, and have a red, purple, swelled base; they are about the size of a sixpence, and vary in number; the pustules become purulent about the third day, and begin to dry about the tenth or twelfth, forming thick scabs, which leave well-marked cicatrices. It was at one time supposed to be the origin of cowpox, but subsequent experiments have disproved this. Its treatment consists merely in rest and mild local applications.

The prognosis in glanders is very unfavorable; recovery rarely taking place unless early treatment be adopted, and in only mild cases of poisoning, where the activity of the virus is weakened.

The post-mortem appearances have been well described in two recent cases,[1] in both of which there was absence of nasal discharge. One of the patients died on the twenty-first day. The blood was found fluid, the muscles soft and rotten, the cervical and left parotid glands suppurating; the lower part of the right lung quite solid with gray hepatization; its tissue completely broken down and infiltrated with purulent fluid; the left lung studded throughout with numerous patches of a slate color and of the size of hazel-nuts.

The second patient died on the thirteenth day; there was no affection of the lymphatic glands, but suppuration in the muscles of both calves of the leg and local abscesses in other parts of the body, chiefly in the muscles; the joints were free from suppuration; there were recent patches of lymph in the pleura; lobular pneumonia in the base of the upper lobe of the right lung, in a state of gray hepatization; the lower lobes of both lungs throughout contained smaller hepatized masses: the liver was free from disease.

Respecting the seat and nature of the disease there are several opinions. Some regard it as a purely local affection derived from atmospheric causes and engendering oxidation and acidification of the secretions, involving chiefly the lymphatics of the nose. Others consider it to be more often a spontaneous and primitive change in the blood, basing their opinion upon the fact that the peculiar secretion in glanders, when injected into the blood of a sound horse, produces the disease. Others, again, assert it to be a tubercular disease.[2] Of late years it has been suggested that it is a kind of pyæmia, from the absorption of pus, and not a specific disease.

In man as well as in the horse the disease arises from contagion, and the most common medium is the nasal discharge, and the discharge from farcy swellings. It may be spontaneously developed in the horse, but never is in man; but once communicated by the horse to man, it can be communicated from man to man. Ac-

[1] Dickinson, Lancet, March, 1869. Poland, Medical Times and Gazette, March, 1869.

[2] M. Villemin (Études sur la Tuberculose, Paris, 1868, p. 431) considers glanders to be the nearest approach to tuberculosis; he speaks of the farcy bud, the tubercular granulations, the caseous engorgements of the glands, the caseous pneumonia, etc., as all similar to the characters of phthisis. As we have an acute and chronic phthisis, so we have an acute and chronic glanders. Glanders and tubercle are closely allied, and must be looked upon as nearly related species of the same genus.

cording to some, the poison may be communicated through the blood, and Viborg states that it may be also by the saliva, urine, and sweat. Langenbeck found a peculiar fungus in the nasal discharge, which he considered to be the medium of contagion; this, however, has been proved to be accidental. Of the chemical nature of glanders-matter nothing is known.

Although the virus must come in direct contact with a wound or abraded surface, or fall upon some thin and delicate membrane, like that of the nose, in order to become absorbed, yet cases are recorded in which the surface was intact, and the disease produced by the wiping of the face with unclean hands or cloths.

Youatt states that there is not one-tenth part of the ravages from glanders now which prevailed thirty or forty years ago, and, generally speaking, it is now only found as a frequent and prevalent disease where neglect and filth and want of ventilation exist. He attributes the disease in the horse to the following causes: improper stable management, viz., want of ventilation, ill-drainage, bad pavement, want of cleanliness and comfort; anything that injures or impairs the vital energy of the nose, such as fracture of the bones of the nose, violent catarrh, prolonged discharges from the nose; want of regular exercise, or excessive and undue exercise, as after a hard day's chase, or at the close of a severe campaign. Atmospheric influences have somewhat to do with its prevalence; thus it is not so frequent in summer as in winter, the air in the stables being then not so close or so foul, or so liable to alterations of temperature; and there are some remarkable cases on record of the connection of moisture or moist exhalations with the cause of glanders. Hereditary predisposition has been mentioned by M. Dupuy, and supported by decisive cases.

The treatment in the horse is thus alluded to by Mr. Youatt:—

"Wherever there is a glandered horse, or even a suspected one, prophylactic and preventive measures must be studiously adopted, great care and cleanliness, avoidance of all unnecessary contact, and especially sleeping in the stable; all wounds and excoriations should be well protected, and after unavoidable contact with the animals, or even the surrounding articles, a thorough and frequent ablution should be made. Great care must also be taken to avoid any discharge from the nostrils, during the sneezing of the animal, as it might be conveyed to the face, or eyes, or nose. In the horse, the disease may be avoided by providing cool and ventilated stables, good and efficient drainage, regular exercise, occasional green-meat in summer, and carrots in winter."

Mr. Youatt continues: "Considering the degree to which this disease, even at the present day, often prevails, the legislature would be justified in interfering by some severe enactments, as has been done in the case of the smallpox in the human subject. Where the life of a valuable animal is at stake, and the owner adopts every precaution to prevent infection, he may subject his horse to medical treatment; but in ordinary instances he is not faithful to his own interests, or that of his neighbors, who does not remove the possibility of danger in the most summary manner."

When the disease has become actually developed as acute glanders, there are no certain remedies. With regard to the treatment in the horse, Mr. Youatt writes: "There is scarcely a drug to which a fair trial has not been given. Blue vitriol and Spanish fly have held out the longest. Biniodide of copper has lately been used, but is not to be depended upon. The remedial measures to be resorted to are, a pure atmosphere, etc., considering that it is the peculiar disease of the stabled horse." Injections into the nostrils, and even trephining of the frontal sinuses for more effectual contact, have been had recourse to. "But," Mr. Youatt adds, "while glanders is incurable, farcy in its early stage and mild form may be successfully treated. As a general rule, and especially when the buttons or buds are beginning to appear, a mild dose of physic should be first administered. The buds should be carefully examined, and if any of these have broken, the budding-iron, at a dull red heat, should be applied. If pus should be felt in them, they should be penetrated with the iron. These wounds should be daily inspected, and if when the slough of the cautery comes off they look pale, foul, and spongy, and discharge a thin matter, they should be frequently washed with a strong solution of corrosive sublimate dissolved in rectified spirit. When looking healthy, friar's balsam is to be used. The constitutional measures are, the employment of bichloride of mercury, combined with tonics; cantharides, with vegetable bitters; biniodide of copper, employed as a stimulant and tonic. Together with these remedies, good air, full allowance of corn, green-meat, and carrots must be employed.

The treatment of the disease in man is likewise extremely unsatisfactory, for there are no certain remedies. Iodine and its preparations have been employed; Fowler's solution of arsenic and other mineral drugs are recommended, creasote, turpentine, etc. But the best constitutional treatment to be adopted seems to be that based upon general principles, viz., the alleviation of the concomitant symptoms, such as the distressing thirst, and the supporting of the powers of life by fresh air, generous diet, stimulants, acidulated draughts, and tonics in the shape of quinine or iron. At the same time local measures must not be disregarded in order to arrest the progress of the local affection, and change its character if possible; these are highly important, and especially where the disease assumes a chronic form. Strong creasote

solutions, nitrate of silver solutions, and other powerful astringents, are to be injected into the nostrils, or sponged over the entire surface. Solutions of chlorides and the chloruret of potash have also been recommended as injections and gargles, as also camphor and nitro-muriatic acid; turpentine embrocations and fumigations with volatile stimulating antiseptics, conveyed through the medium of warm aqueous vapor. When knotty tumors, boils, or abscesses form, these should be early and freely incised and the contents evacuated. In the case from which the second illustration is taken, the man was well aware of the nature of his disorder, styling it farcy; and as he was in the habit of treating horses suffering from the disease by opening the tumors and burning them, so he wished the same plan to be adopted on himself. He expressed himself dissatisfied that it had not been done: however, in the present instance it would have been cruel to have gashed this man all over from head to foot, and then probably have missed some of the deeper-seated collections of matter.

WOUNDS OF VESSELS.

By Charles H. Moore, Esq.

Revised by Lewis A. Stimson, M.D.

Hemorrhage.

All wounds of vascular parts are necessarily attended with hemorrhage from the vessels which have been opened by the injury. In the first moments after the infliction of the wound, the violence and amount of the bleeding depend upon the number and the smooth cutting of the opened vessels. In the majority of cases, the bleeding is stopped by the natural powers of the blood and wounded parts; and it is important only when many or large vessels are concerned, or when the bleeding continues. Injuries of the larger arteries and veins form the subject of separate portions of this work; the more frequent hemorrhages of various kinds, which occur under other circumstances, will now be considered.

In all slight wounds the blood oozes forth evenly, without jerking motion; and being composed of the mixed contents of both arterial and venous twigs, it is intermediate in color between them. Under ordinary circumstances, such hemorrhage gradually and spontaneously ceases; but in others it persists. It persists, if the flow of blood to the part be encouraged by a high temperature, or by the force of gravitation on the blood, or by the muscular or the expiratory efforts of the patient. If the current of the blood along its natural channels be obstructed, as by pressure on the blood-vessel, the hemorrhage persists. It does so, if the natural contraction of the bleeding vessels be interfered with, or if certain chemical agents or its own peculiar composition prevent the coagulation of the blood. Thus, a superficial laceration of the liver or spleen is in much the same condition as an external wound with a warm sponge upon it; the flow of blood is favored by the high temperature of the interior of the body, and continues sometimes to a fatal extent. Such injuries of the liver bleed inordinately from another cause, viz., that the hepatic veins, not being contractile or surrounded by any loose tissue, cannot close, or even collapse. Obstinate hemorrhage sometimes follows the extraction of a tooth, and the sawing across of the nutrient artery of a bone in an amputation. Whether previous disease have altered the tone of the artery or not, the fact appears to be that the divided vessel cannot contract or collapse in the dense canal within which it is lodged. Varicose veins of the lower extremity, and those of the rectum, bleed, when they burst, with a double force; since, being unprotected by valves, they possess both an onward and a retrograde current of blood towards the part which has given way. The struggles and cries of a patient greatly increase the bleeding from wounds of the almost valveless veins of the head and neck, especially if the person be restrained in a recumbent posture.

Hemorrhage, whether it declare itself by the external discharge of blood from a wound or through any of the open

canals of the body, or be concealed by the accumulation of the blood within a closed cavity, is attended by general symptoms, sufficient to indicate what is going on. The ruddy tint of the integument departs; the lips and conjunctiva appear blanched; the withdrawal of blood produces a disproportion between the size of the arteries and their contents, and the pulse is at first small; it also increases in frequency, the heart laboring to make up in rapidity of action for the small quantity of blood which it sends forth at every beat. A feeling of languor, yawning, throbbing of the temples, impressions of noises and of light come on; the surface loses warmth; and at length the heart and brain somewhat suddenly cease from their functions, the patient becoming unconscious and falling down, and the pulse being nearly, or for a time completely, interrupted. The breathing during this syncope is very feeble, and performed only by the diaphragm. If the flow of blood continue under these circumstances, the patient dies; but if, as is far more commonly the case, its issue should cease, rapid coagulation takes place at the orifice of the vessel, and the plug thus formed prevents the immediate recurrence of the bleeding. An attack of vomiting often accompanies the return of consciousness. The heart resumes its function, at first feebly, and afterwards with frequency and even with violence. The pulse is jerking, soft, and easily compressible, the wall of the artery being soft and large, and contracting very incompletely after the small wave of blood has shot through it. All the soft tissues of the body lose their usual tension and plumpness, and the features of the face are thinned. These changes result partly from the mere absence of the blood, as a tumor feels less hard after its removal from the body than when injected by a continuous current of blood; partly also they are due to the diminution of the fluid constituents of the body, which have been rapidly absorbed for the purpose of refilling the bloodvessels. Extreme or repeated hemorrhage, such as occurs from the opening of an artery or from lacerations of internal organs, occasions faintness, sighing, restless tossings, with the other symptoms already described, sometimes amaurosis, and at length delirium or convulsions. The actual death may take place suddenly upon the patient's assuming the erect posture, or lifting the hands above the head; or it may be gradual and preceded by insensibility, with stertor and puffing of the cheeks, and copious cold perspirations of several hours' duration. The occurrence of death during hemorrhage, however, cannot always be ascribed to the quantity in which the blood has escaped, since patients differ much in their endurance of loss of blood. Infants suffer most from this cause. One adult may fall into syncope at the abstraction of twenty ounces of blood; another, standing, with his back towards a large fire, will bear the loss of more than fifty ounces before feeling faint. And in other instances it may happen that death is not due so much to the quantity of blood lost as to the hemorrhage being associated with terror, with other physical disease, or with the influence of a suicidal mind.

The change in the density of the blood, which has been described as a result of continued hemorrhage, renders it unnaturally liable to escape from the bloodvessels. In persons who are suffering from hemorrhage in one situation it may accordingly happen, that smaller extravasations of blood take place in distant tissues. Such secondary bleeding occurs in uninjured parts of the body, and in persons who may be assumed to be healthy, since it will follow when the primary hemorrhage has been the consequence of a wound. Thus, I have observed ecchymoses in distant parts of the body of a patient who had died of traumatic abdominal hemorrhage. Dr. Denman reported an instance of fatal cerebral apoplexy in a patient who had suffered from uterine hemorrhage for seven years; and Mr. Travers another, which occurred during the performance of venesection for an attack of pneumonia.

The hemorrhages which have been considered above are such as occur in persons of ordinary health, and are not modified by any peculiarities in the construction of the bloodvessels, the composition of the blood, or any more occult or constitutional cause. Yet there are not a few instances of hemorrhage, for the treatment of which the aid of the surgeon is sought, and in which, without a visible breach of the surface, the blood pours forth from mucous membranes or from the skin, or accumulates, as it is extravasated in the natural serous cavities, or in the areolar and muscular tissues.

[The hemorrhages known as *neuropathic* are varied in form, often preceded by eruptive symptoms, sometimes marked by an intermittent or periodic course, and associated with other nerve symptoms, such as hysteria, epilepsy, and pain. They may be produced in perfectly healthy persons by sudden violent emotions, fright, etc. Lancereaux mentions two remarkable examples. A young cabinet-maker, engaged in moving a valuable piece of furniture, nearly let it fall, and was very much alarmed by the accident. The same evening he had a violent epistaxis (having never had any before), which was repeated on the following

days, and accompanied by bleeding from the gums. Two months afterwards he entered the hospital in a state of extreme anæmia, with discolored skin, pulpy gums, and ecchymoses on the limbs. Epistaxis or bleeding from the gums occurred every day; and a few days after admission he lost more than a pint of blood from the nose, and died soon afterwards.

The second case was that of a man arrested in Paris during the Reign of Terror, but promptly released. When he reached his home his body was found to be covered with red spots, varying in diameter from one-eighth to three-quarters of an inch. He lost a little blood from the nose, and two days afterwards passed a large quantity from the bowels. This alvine hemorrhage became excessive, and he soon died.]

The prevalent hemorrhage of young persons is epistaxis; that in adult life is hæmoptysis, hæmatemesis, or hæmaturia; while the commoner source of bleeding in declining years is the rectum, and in the aged the brain. The assignment of hemorrhage in particular situations to separate periods of life is, however, only generally correct. Children may die of cerebral apoplexy, and epistaxis may put life in danger after fifty years of age. Of the several forms of bleeding above enumerated, a sufficient cause is found in disease of the bleeding part, or of some organ closely connected with it. Cancerous growths, tubercular ulcerations, mere overfilling of the veins of a superficial membrane, if permanent, explain many such hemorrhages. Subconjunctival and retinal ecchymoses thus occur during a cough, and in obstructive heart-disease. But these sometimes, and oftener the other examples of spontaneous bleeding, cannot be thus explained. They are brought about by some less manifest defect in the blood, the bloodvessels, or the bleeding tissues, or by the influence of some constitutional fault or necessity.

That hemorrhage should sometimes persist in an inordinate degree, as a consequence of a defective coagulating power on the part of the blood, might be expected from the number of known instances in which no coagulation whatever takes place. The entire absence of clots in the heart and bloodvessels of certain bodies, when examined after death, whatever the cause of their absence, prepares us to find such deficient coagulating power occasionally during life.

Again, we might readily attribute some influence in the production and continuing of bleeding to a defective construction of the bloodvessels, when we regard the cases of Wilson, Blagden, and Roux; in which, without other assignable cause, hemorrhage from such vessels proved fatal. Wilson, in his Lectures at the College of Surgeons, in 1819, mentioned his having found the arteries possessing but half their natural thickness in a person who had died of uncontrollable hemorrhage.[1]

Mr. Blagden's case may be thus abridged. The patient, when a boy, bled for twenty-one days from the alveolus, after the extraction of a tooth. Whenever he cut himself accidentally, hemorrhage took place to an extraordinary amount, and was difficult to stop. At twenty-six years of age he received a slight wound of the forehead, and an enormous bleeding issued from a wounded artery. It was stopped for a time by the application of a ligature on either end of the vessel; and this was observed by the surgeon to be very thin in its coats, and like a vein rather than an artery. Kali purum was applied, and it stanched the bleeding, but occasioned extensive sloughing. In the following year he again had a tooth extracted, and suffered profuse hemorrhage from the alveolus. Lunar caustic, blue vitriol, cold, plugging the alveolus, the actual cautery, all were tried, but only temporarily controlled the bleeding. On the sixth day he was greatly exhausted, and the bleeding returned. Sir B. Brodie tied the common carotid artery; yet the hemorrhage continued. The wound made in the operation bled very little at first, but in a few minutes it also began to bleed profusely. No single vessel could be observed bleeding, but there was a general oozing from its surface, which was for a time suppressed by the application of ice. On the seventh day, however, the patient died of a return of the hemorrhage.

The carotid artery had several opaque white depositions on the outer surface of its inner coat. The temporal and some other branches of the external carotid appeared to have thinner coats than usual, and to be nearly transparent.[2]

If, again, tissues adjoining and involved with the bleeding vessels be examined, some share in permitting at least, if not in actually causing, the obstinate hemorrhage may appear to be assignable to them. Wounds, when such bleeding follows wounds, do not readily undertake processes of repair. The granulations, which subsequently form on them, are large and flabby; they bleed readily and long upon the slightest injury, and are sometimes distended like bladders by hemorrhage into their substance. Such wounds heal slowly, and sometimes not at all; they may be covered for a long time with a blackish scab, or with a waxy matter or plug. If a cicatrix form over them, it is very thin, and, even when completed, may permit a fresh oozing of

[1] Lane, Lancet, 1840.

[2] Med.-Chir. Trans., vol. viii., p. 224.

blood to take place through it. What is the condition of the Schneiderian membrane during epistaxis, and of other mucous membranes which bleed when not wounded, may be inferred from the appearance of such bleeding scars. If the blood be sponged away, fresh minute drops are seen to collect upon very small and numerous blackish orifices, and, after uniting into a larger drop, to flow off. A similar appearance was presented by the skin of the finger of a young woman, from which severe spontaneous hemorrhage sometimes took place.

But, although there may in different cases be a fault in the blood, or the vessel, or the tissue, yet neither one nor all of these can be regarded as the principal and final cause of the hemorrhages under consideration. The following are some of the circumstances in which they occur.

The regular monthly flow of somewhat altered blood from the inner surface of the uterus is in some persons interrupted, while at the same time blood oozes from the most various parts of the body, from any of the mucous membranes, from the skin, or from an unhealed ulcer or a cicatrix. In the punctuality of its monthly recurrence, in the similarity of its duration; in the quantity of fluid blood which transudes, in the relief it affords to the system from the ordinary symptoms of amenorrhœa, this hemorrhage shows its identity with that of the natural catamenia, and the propriety of its being considered to be a substitutionary, or, as it is termed, a vicarious, menstruation. The proof that this is its real nature and cause may be regarded as complete, if we add that the hemorrhage so named occurs in a part, which both before and afterwards may be without a trace of ulceration or wound, and that it ceases when the uterus resumes its natural periodical function.

Periodical hemorrhage is by no means restricted to persons of the female sex, and is not in them universally associated with the cessation, or even with any ascertained disorder, of the menstrual function.

I have been informed by Mr. Holmes of the case of a woman, in whom hemorrhage went on for many years from an unhealed part of a stump. No remedies, constitutional or local, availed to stop it, and the stump was amputated with the hope of obtaining a healthy surface. The hemorrhage recurred as before, from the second stump, and the case was finally given up as hopeless. The menstruation in this patient was regular, and its occurrence had no perceptible effect upon the bleeding. The blood also appeared to be natural, and the arteries sound. There was no unusual amount of bleeding at either amputation, or trouble with secondary hemorrhage afterwards. Neither was there any evidence of the hemorrhagic diathesis.

In some persons a periodical hemorrhage occurs annually; in others at shorter intervals. Some such bleedings are even hereditary; especially is this the case with hæmorrhoids in men. Led by the exactness of its monthly recurrence, and by some other less obvious characteristics, Gall and Chomel claimed for the hemorrhage occurring in some male patients the menstrual character. The former even asserted that there naturally is periodic change in the male system, corresponding in time and nature with the monthly excitation of the female, and unlike it only in being unaccompanied with hemorrhage. With regard to other cases of recurrent constitutional hemorrhage, of which no local or general cause can be ascertained, it has been surmised that the production of blood in such persons exceeds the quantity expended in the nourishment of their tissues, and that hemorrhage occurring when the surplus of blood has accumulated in the vessels is at once the consequence of the repletion, and the means of its relief.

[The spontaneous hemorrhages which are probably due to some alteration in the quality of the blood usually come from the free surfaces, the mucous or serous membranes, without previous congestion, are usually repeated at irregular intervals, and are apparently by diapedesis. Cirrhosis of the liver is a frequent cause, and as the bleeding, although most common in the distribution of the portal vein, is not confined to it, there must be a general cause, and not merely a mechanical one, possibly, according to Lancereaux, absorption of the bile. Among the other causes are some poisons, phosphorus, iodine, arsenic, and septic substances.]

An uncontrollable propensity to bleed is the chief character of the disease commonly known as the Hemorrhagic Diathesis. Upon the slightest breaking of the surface, a scratch of the gum or a prick of the finger, the blood leaks forth incessantly, and no more effort to stay its flow appears to be made either by contraction of the bloodvessels or by clotting of the blood, than if the stream were water, and the tube it flowed through were a metal cock. A case of this kind is occasionally met with in England. Two of a family of seven children were recently admitted into the Middlesex Hospital for very long-continued and exhausting hemorrhage, proceeding from trifling wounds of the gum and finger; a third child, of the same family, having already died from bleeding after biting its tongue, and others having exhibited the hemorrhagic tendency. But instances of the disease are rare in any country, in comparison with their frequency in certain

parts of Germany, and more numerous and complete records of its characters have accordingly issued from that than from any other country.

It is sometimes observed that the characteristics of hemorrhagic diathesis may be induced in a young and previously healthy person by the privation of fresh air, light, and nourishing food, and by confinement in a damp low situation; and that they will disappear again upon replacing the patient in conditions favorable to health. It does also undoubtedly happen that without exposure to unhealthy influences, and without traceable hereditary taint, the hemorrhagic diathesis shows itself for the first time in adult life, and remains as a persistent disease. But most commonly it appears as congenital and inherited. It does not select manifestly unhealthy persons, or exclusively affect any particular period of life. Infants die of it as their navel-string separates; growing children and adults lose enormous quantities of blood from it, and at length may bleed to death. Some persons survive till past sixty years of age, and though they have bled severely at various periods of their lives, die at last of disease unconnected with the hemorrhagic peculiarity of their constitution. The diathesis probably exists equally in the male and female children of a family, although it does not equally show itself; for, while the hemorrhages come on early amongst the former, and are fatal to them in their boyhood, the girls mostly survive the age of childhood, and exhibit the diathesis either by themselves dying of some inordinate hemorrhage from their generative organs, or by giving birth to children who present evidences of the same diathesis. Men having the hemorrhagic tendency, who marry healthy wives, do not appear to convey the tendency to their offspring.

The bleeding is sometimes spontaneous, sometimes the result of a wound. In the former case it may be periodical: there is an instance of its recurring annually in a child on the fourth day before his birthday, and on the fourth or fifth occasion proving fatal. But whether the spontaneous hemorrhages recur at regular or irregular intervals, they always continue for a long period; they drain the body of nearly all its blood, and cease only with life, or from long-continued syncope, which appears like death. When the hemorrhage arises from a wound, it differs in its severity according to the nature of the injury. Clean wounds sometimes bleed moderately, even in persons who are known to have the hemorrhagic tendency, and venesection is sometimes resorted to without injury as a means of relieving them from a threatening attack of spontaneous hemorrhage. Yet even such wounds in these persons cannot be regarded as free from danger, since some have died of bleeding from incisions made in surgical operations; and an instance is recorded in which a boy, who had been bled, died in his bed of hemorrhage from the lancet-wound. The bandage remained firmly applied upon the wound. The most certain and uncontrollable hemorrhage is that, however, which happens from lacerated wounds, and from those which have been kept from closing by the sucking of a leech or by a cupping-glass. Small contused and lacerated wounds bleed more than larger ones; and it has happened that a small wound of this character has ceased to bleed when a surgeon (Fordyce) has enlarged it by incision. The most commonly fatal injury amongst these persons is the extraction of a tooth.

There is no obvious fault in the blood which issues from a recent wound. It coagulates after flowing off, though it does not do so to any effect in the wound itself, and it possesses an equal quantity of fibrin in this diathesis with that in the blood of other persons. But as the hemorrhage continues, this character of the blood is lost; it no longer coagulates, it becomes thin and watery, and leaks forth more readily, if not more abundantly, than ever. The importance of arresting the bleeding from wounds as early as possible is thus shown, since hæmostatic remedies become of less and less avail the longer the blood flows.

The subjects of this peculiar disease are likewise liable to hemorrhages in various tissues, to ecchymoses on all parts of the body, and to the formation of bullæ on the skin, which also become filled with blood. The readiness with which blood oozes into the tissues in these cases is of no little importance in a forensic point of view, since the appearances presented by a body thus marked might lead to the erroneous supposition that a very considerable and culpable amount of violence must have been inflicted. Indeed, the disease materially affects the whole social relations of the sufferer. However adapted by mental vigor or by physical strength, he is entirely unfitted by it for any occupation which might require him to handle edged or pointed tools.

In early childhood, and sometimes after the full growth has been attained, these "bleeders," as they are called in Germany, are prone to affections of the joints, presenting some of the characters of rheumatism. The disease of the joints may vary in different individuals between mere pain and the most considerable swelling; but in many families no individual, who has the hemorrhagic diathesis, fails to

suffer also from some degree of the articular disease. Not unfrequently pain will come on in a joint, particularly in spring-time or harvest, and after passing irregularly from one joint to another will settle in the knee, and be followed by a painless enlargement of that joint, not unlike a white swelling. As the joint enlarges, some habitual indication of the patient's diathesis, piles or hemorrhage, for instance, will cease, and not continue so long as the joint continues swollen.

Before speaking of the treatment which these cases require, it may be advantageous to furnish the entire history of a hemorrhagic patient. I select one from Grandidier's interesting monograph on the disease.[1]

"Heinrich M., forty-four years of age, the son of a man-servant still living, is a strongly-built man, five feet nine inches in height. The hair of his head and beard is black, his eyes are of a clear blue color. He was delicate in his early childhood, and as he grew up he suffered much from rheumatic affections of the joints; his feet especially remain weak from this cause, and they still prevent his walking quickly. From the first year of his life he has been subject to hemorrhages, both spontaneous and traumatic. Those which were spontaneous issued from the nose and the gums in his earlier years, but more lately from the urethra and rectum. The attacks of bleeding are always preceded by great restlessness, by pulsating and throbbing of all the arteries, and by a feeling as if they would burst. He states that he is warned of the approach of the bleedings some week or fortnight before by the continual odor of fresh blood in his nostrils. At the expiration of the period of warning, slight hemorrhage from some part of the body begins, and usually continues a fortnight or three weeks. At first he is able to continue up and about; but after a week he is compelled to take to his bed, and from that time the bleeding increases in severity, and continues, whether he wake or sleep, until at length the blood is quite clear and appears like lymph. In a state of prostration and unconsciousness, he then lies as one dead for several days. When the flow has ceased, he slowly returns to life and consciousness; but many weeks pass before he loses his paleness and the feeling of languor and exhaustion. Gradually, however, as appetite returns, he begins to make blood again, and after a few months he once more blooms 'like a rose.' He is bright and clever, and has a good deal of mechanical ingenuity. The sexual passion was never inordinate in him, as is reported to have been the case with one of Wachsmuth's patients. When three years of age he fell and bit his tongue; the wound bled for eight days, and the enormous hemorrhage could not be stopped without surgical help. Up to his seventh year he bled frequently and severely from the nostrils; after that age the blood issued from the gums. The gum would become congested and swollen, and at some one spot upon it drops of blood would appear; after a time smart hemorrhage would come on, and continue for a fortnight or three weeks, until he lost consciousness. In his nineteenth year he cut his thumb, and the wound went on bleeding for three weeks. As he was without surgical assistance, and all domestic remedies proved useless, he had a bandage applied round the arm near the wrist. The bleeding stopped, indeed, but such swelling of the hand and arm came on that he was obliged to have the ligature removed. The hemorrhage then recurred, and continued until he was perfectly exhausted. In another week the wound had cicatrized.

"After he had reached the age of thirty-one, the gums rarely bled, and hæmaturia became the prevalent hemorrhage. It was always preceded by severe dragging pains in the region of the kidneys; the blood which passed by the urethra was sometimes fluid, sometimes coagulated. Two years ago he had continuous hemorrhage from the gums for two days, and for three days subsequently hæmaturia. On the fifth day, being quite exhausted, he took to his bed. Towards morning he was awakened by the action of his bowels, and in the course of an hour discharged by the anus more than a pailful of pure blood. The bleeding was then at an end, for, as he expressed it, 'I had no more.' He lay for the next twenty-four hours without consciousness or movement, and as if dead; and was not in a condition to walk again for eight weeks. On one occasion the lungs furnished the blood in large black lumps. This propensity to hemorrhage is recognized in his family as an inherited disease, there having been three other instances of it amongst his mother's relatives. His grandmother's sister's son bled to death in his thirtieth year, from a small scratch in the neck. His mother's brother died in a short time of hemorrhage from the nose and mouth. His mother's sister's son is also the subject of hemorrhages, but is still alive. All the 'bleeders' of this family from their first year of life had raven-black hair."

The consideration of the treatment of this disease involves at least two questions: its general management, with the view of preventing the attacks of bleeding and of obtaining a radical cure, and the propriety and means of arresting existing hemorrhage. The former question has been especially studied by Wachsmuth,[1] who wrote the first monograph on the subject. He had the painful opportunity of watching and treating the disease in one of his wife's brothers, and two boys of his own family. Other relatives of his wife had also died of hemorrhage; one of them, a girl of twenty, from the rupture of the hymen.

[1] Die Hämophilie, oder die Bluterkrankheit. Leipzig, 1855, p. 28.

[1] Die Bluterkrankheit, von Carl Otto Theodor Wachsmuth. Magdeburg, 1849.

From the observations which he made upon the nature and progress of the disease, he concluded that two essential and congenital conditions contributed to it—an exalted vitality of the blood, and a delicate construction of the capillaries. Many of the circumstances of the disease appear to support this conclusion. α. Its intermittent character. β. The strong action of the arterial system, and the mental and bodily excitement, which forebode the attack. γ. The immunity from excessive hemorrhage, even after wounds, in the intervals between the attacks. δ. The rare occurrence of bleedings in persons who have some established outlet for their superfluous blood, as men with hæmorrhoids, and women during their years of menstruation. ε. The facility with which bleedings are sometimes prevented or arrested by means which lower the vitality of the blood, as spontaneous diarrhœa, smart purging, and, in one remarkable case, excessive sexual indulgence. ζ. The proneness of "bleeders" in their earlier years to inflammations of the lungs; or organs, that is to say, concerned in purifying this highly vitalized blood. η. The readiness with which ecchymoses form under the skin from very trifling pressure or injury. The indications for general treatment follow from this view of the nature of the disease—namely, to lower the exalted vitality of the blood, and to raise the tone of the capillaries.

The mode of following these indications may, perhaps, be best shown by Wachsmuth's account of the treatment of his eldest boy. One or two traumatic hemorrhages during the first year of his life could only be stopped by the actual cautery. Spontaneous bleedings afterwards came on, and put the child's life in danger. "As all the internal and external styptics proved of no service, the thought occurred to me to try an infusion of arnica. The action of this remedy gave me much satisfaction; it arrested the bleeding in the course of three or four days, while without it the blood would flow for twice that period, and cease only upon the occurrence of syncope. I had already tried Glauber's salts, not only on account of Otto's recommendation, but also because I had observed smart purging to stop the bleedings. My brother-in-law used to be much benefited by it; but my little boy, though also relieved as to the hemorrhage, was too much exhausted by its use. . . . I kept the child mostly out of doors, had him washed or bathed every day in cold water; ordered him a light unirritating diet, chiefly of animal food, and gave him the carbonate of iron regularly, with the exception of a pause every four weeks. I subsequently employed the cod-liver oil. When a considerable period has passed without any hemorrhage, and the boy showed much excitement, his face and ears flushed, etc., I gave him Glauber's salts for several days together in smartly purging doses. For arresting hemorrhage, I have long since substituted for arnica the secale cornutum" in five grain doses every half hour.[1]

In treating the spontaneous bleedings, it must not be forgotten that they are of a critical nature; and that if arrested too soon, they are sometimes replaced by hemorrhage in some important organ. "A short time ago, during my eldest boy's spring attack of hemorrhage, I made some experiments as to the critical import of the bleeding. The preliminary symptoms had existed for a long time, and I gave him only small doses of Glauber's salts during the period of a fortnight. No hemorrhage occurred. For the following week I left the child free from all medical treatment. The tokens of congestion, which had almost entirely subsided, were now renewed; still I did not interfere, and after a few days a smart hemorrhage took place. I then gave the secale cornutum, and the bleeding continued till evening. The boy was very restless in the night, the orgasm of the blood became more and more manifest, and at noon of the following day the bleeding recommenced. When it had lasted three days, I gave the ergot again, and the hemorrhage ceased. From that time no further excitement in the vascular system recurred, and the boy remains well."[2]

The hemorrhages arising from wounds in these subjects do not appear to yield to the same treatment as those which are spontaneous. Glauber's or Epsom salts do not abruptly cut them short, and too often the ordinary styptic applications disappoint the surgeon by only arresting the flow of blood for a time, or by even failing altogether to do so. The actual cautery is the least uncertain styptic in these cases. Long-continued pressure has occasionally proved effectual in stopping bleeding from the alveolus after the extraction of a tooth. These and the other measures recommended for the general treatment of hemorrhage in this article may be adopted.

[Verneuil strongly recommends full doses of quinine. In a discussion before the Société de Chirurgie[3] upon the persistent hemorrhage following the removal of a tooth, he mentioned a case in which 15 grains of quinine promptly arrested such a hemorrhage after other means had failed.]

Treatment of hemorrhage.—The following rules will be found applicable to the treatment of ordinary hemorrhage.

In many cases of moderate hemorrhage the blood which has escaped and coagulated in the wound appears to be a chief cause of the continuance of the bleeding;

[1] Loc. cit., pp. 10, 11. [2] P. 55.
[3] Bull. de la Soc. de Chirurgie, 1879, p. 392.

and completely removing the clot and exposing the bleeding point are speedily followed by the cessation of the hemorrhage. The importance of this practice cannot be overrated; it is applicable to almost all cases but those of severe arterial hemorrhage, and is even successful in some instances of arterial bleeding from the palm of the hand. The exposure of the surface of stumps, and other surgical wounds, to the air, for some hours after operation, has almost invariably the effect of preventing secondary hemorrhage. The wound may be closed after six or more hours by means of sutures, introduced, but not tied, at the time of the operation. I have never known it requisite to re-open a stump or wound so treated, and the contraction of the soft parts during the exposure is very remarkable. In the Medico-Chirurgical Transactions will be found a valuable illustration of the advantage of exposing bleeding vessels. "A man was admitted into St. Bartholomew's Hospital for a wound of the calf, which bled unceasingly within the integuments, until the extravasated blood had raised them from the ham to the heel. Mr. Lawrence laid open the whole of the vast cavity and turned out the clots, but he could find no single bleeding vessel. The hemorrhage ceased at once, and did not return."[1] [In like manner oozing from the surface of a large abscess, which has followed evacuation of its contents through a small incision, may be instantly arrested by freely opening the sac and exposing it to the air.]

The elevation of the bleeding part greatly influences hemorrhage, and should be attended to, whether the bleeding point be in the pelvis, the head, the neck, or any of the extremities.

Cold applications to the wound and adjoining parts appear to act in two ways in restraining hemorrhage: they encourage contraction of the bleeding vessel and cause it to be compressed by the shrinking of the soft parts; and they also diminish the quantity of blood which arrives at the bleeding point. Ice is, accordingly, a valuable auxiliary in the suppression of hemorrhage. It may be laid upon a wound, introduced into it, passed within the rectum, or otherwise applied, as suits the circumstances of the case. A current of air is also very efficacious.

[Attention has been drawn within a few years past to the value of *hot* water as a hæmostatic; and abundant experience is on record in regard to it. It probably acts as a stimulant both to the walls of the vessel and to the nerve-fibrils in the wounds. When the wound is large, hot water has the great advantage of not inducing shock.

The method of application is the same as that of cold water, by sponges, or pledgets of lint, tow, or absorbent cotton. The temperature generally used is the highest that can be borne by the hand.—P.]

Well applied pressure will stop great hemorrhage. It should be accurately directed upon the leading vessel, and should, if possible, though not necessarily, be made in the wound. The first pad must be small and firm, and should be laid on the bleeding orifice without any intervening clot. Each additional pad should be larger than the one beneath it, but need not fill the wound; and the whole should be firmly bandaged. Care is required to adjust the pressure upon the pads to that amount which shall be sufficient to stay the bleeding, and not occasion sloughing of the compressed parts, or of the limb below them. The pressure on the pads over a wounded palmar arch is sometimes effected by turning the bandage over the two ends of a stick or yoke, which crosses the back of the hand. If the tension of the bandage be not moderate, the compressed soft parts of the back of the hand may slough. It is sometimes advisable to support the distant parts of the limb, and each finger or toe separately, by bandaging them before compressing the pads.

Medicated astringents act directly upon the flowing blood. They can be useful only in the wounds of vessels of moderate size, and when they reach the blood as it issues from the orifices of the vessels, and cause it to coagulate into a firm plug. A small pad of lint, soaked in the oil of turpentine, the perchloride of iron, Ruspini's styptic,[1] or the tincture or infusion of matico, should be laid and held on the bleeding point. Turpentine, lead, opium, gallic and tannic acids, given internally, dispose the whole mass of the blood to coagulate, and thereby assist to stop hemorrhage from any particular point. The bleeding arising from the hæmorrhagic diathesis is sometimes controllable by a few doses of the oil of turpentine [or a large dose of quinine]. A full dose of crude opium is often of great service in arresting that oozing of blood from a number of small vessels, which is occasionally observed after a surgical operation, and which is not unfrequently due to inflammation, or to drinking stimulants just before the performance of it.

Other modes of treating hemorrhage arise out of the circumstances of the case. Nitrate of silver, potassa fusa, or the actual cautery, may be applied to the

[1] Vol. xxix., p. 53.

[1] [Said to consist of gallic acid, a small quantity of sulphate of zinc, and opium, dissolved in a mixture of alcohol and rose-water. Dunglison, Med. Dict.—P.]

bleeding point. A small needle may be passed through the skin across a bleeding leechbite, or umbilicus of a child, and the flow finally arrested by firmly applying a figure of 8 ligature.

[Prof. Wm. Detmold recommended, in his lectures upon Military Surgery,[1] a method of arresting hemorrhage from penetrating wounds of the chest which he has also found useful in severe epistaxis, and a substitute for venesection. It consists in the temporary withdrawal of a considerable amount of blood from the circulation by means of a bandage passed about the root of one or more limbs tightly enough to arrest the return venous current, while not obstructing the flow through the arteries. He prefers a stout rubber tube; but if this cannot be obtained, an ordinary bandage, or even a handkerchief will suffice. The bandages should be retained upon the limbs until the bleeding is arrested (usually only a few minutes), or until syncope threatens, and are then gradually loosened. Prof. Detmold first employed this measure in a case of heart disease, with attacks of dyspnœa which had been relieved so frequently by free venesection, that the patient was greatly reduced. He has also used it to arrest or prevent hemorrhage from the lungs. He does not consider it applicable to "bleeders," on account of the danger which exists in these cases that the pressure may cause a slough. This method is said to have been employed also by the ancients for the same purpose.[2]]

In the application of a *ligature* upon an artery, the bleeding orifice is seized with forceps or pierced with a tenaculum, and the open mouth of the vessel is tied above the instrument. There is much convenience in this procedure if the forceps are made broad towards the point, that the silk or thread which is used may not fix the instrument in the knot. It is usual to tie the knot tightly, with the view of dividing the two inner arterial coats, and of strangulating the outer coat. Though necessary in order to procure the separation of the ligature, such force is not requisite to obliterate the vessel. Dr. B. Howard, of New York, published a series of experiments in 1867, showing that an artery became obliterated if only so compressed as to stop the circulation without lacerating its tunics. If the ligature, however, though a metallic one, were left in the tissues, he found that suppuration took place around it. The usual practice is to cut one end of the silk or flaxen ligature short, and to bring out the other at the nearest opening of the wound. My colleague, Mr. De Morgan, however, has of late cut off both ends of the thread, and closed the wound over the knots. He has also sometimes before closing the wound carried the ends of each ligature through the skin lying over the knot. In both ways he has succeeded in obtaining prompt union of the wound. [The carbolized catgut ligature is now very generally used instead of either silk or silver. It disappears by absorption almost invariably, and offers no obstacle to primary union of the wound.]

A new method of occluding arteries was devised by Sir J. Y. Simpson, and published by him under the name of Acupressure in December, 1859. It possesses the merit without the disadvantages of a loose metallic ligature. By this method the artery is not encircled, but pressed on one side by a suitable manœuvre with a pin. The pressure suffices to stop hemorrhage without lacerating or destroying the vitality of the vessel; and long before the pin could set up suppuration, the artery is permanently occluded and the pin may be withdrawn.

The use of the pin requires practice and adroitness, and involves the surgeon in care and attention for a day or two to prevent accidents, which he is spared when once vessels are tied in a knot of silk. For example, four hours after amputation of the thigh, a boy withdrew the needle compressing his femoral artery. The vessel having even already closed, no hemorrhage ensued; but this fortunate event, though a strong reason for preferring acupressure to the ligature, should not be presumed upon in deciding the time for withdrawing the needle or pin. Secondary hemorrhage is not unknown in the practice of acupressure, but it is not more common than after the use of the ligature: and on the whole the results of Sir J. Y. Simpson's invention are far more satisfactory than those of the ordinary ligature. It is chiefly preferable on account of the facile rapidity which can be acquired in its application; of the advantage which can be taken of the natural early closure of the vessels to free the wound from foreign bodies; of the absence of inflammatory reaction and suppuration, in consequence partly of the material of the needles and partly of their short residence in the tissues; of the perfectness of the reparative process, which, if other circumstances be favorable, may ensue; and the consequent reduction of danger from diseases to which persons are liable from open wounds.

Ligatures usually remain in a wound from a few days to three weeks, but needles may be safely withdrawn from arteries of average size in 24 hours, and from a brachial or superficial femoral

[1] American Medical Times, Jan. 7, 1863.

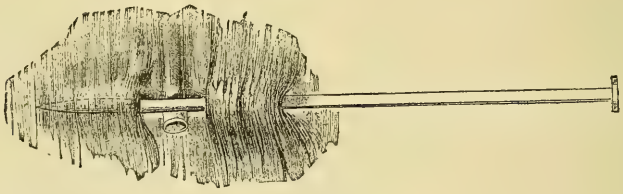
[2] Ziemssen's Cyclop., Am. ed., vol. vii., p. 289.

in 48 hours. In previously exhausted persons, from whose blood adhesive clots may not readily form, it is prudent to postpone for another day the removal of the needles. Thus at a very early period every source of irritation is taken away from the wound, and repair may proceed without interruption. Under acupressure there occur many more instances than when ligatures lie along a wound of primary union, that is, of union without any suppuration, in wounds so large as those of amputation of a limb or a mamma. The advantages above enumerated are of course not absolutely secured by acupressure. Needles, instead of silk, do not give the unhealthy resident in a crowded town the reparative faculty of a healthy countryman, and Aberdeen must in this respect always do its surgeons a credit which is denied to those of Manchester or London. But it does secure among equally healthy people a larger proportion of quick unions of wounds than ligatures permit when used in the ordinary way.

The various manœuvres of acupressure are multiplied by the Aberdeen surgeons, Professors Pirrie and Keith, into seven kinds, but in principle they may be reduced to three. The first, or that by transfixion, acts through the elasticity of the textures which press the needle against the artery: in the second, or acupressure by the twist, the transfixed tissues are further tightened by rotation; while in the third, or method with the loop, the artery is compressed between the needle and a slip-knot of wire.

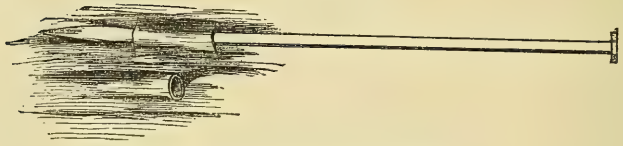
In the first method, a pin or needle, after piercing the tissues, is brought out on the surface of the wound close to one side of the artery, is made to cross over the artery, and then, with its head well lifted, is thrust again into the tissues close to the vessel on the other side. A

Fig. 72.



First method.

Fig. 73.



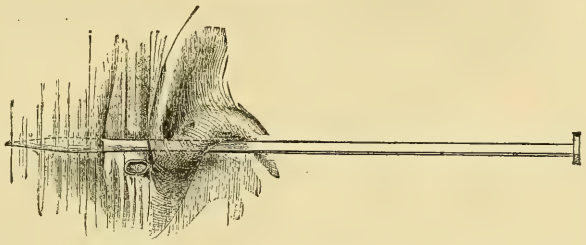
First method—needle introduced.

small part of the shaft of the needle is thus left in contact with the artery, and pressing against it with a force depending on the elasticity of the textures raised at the first and second insertions of the needle. If there be a resisting substance beneath the artery, the needle closes the vessel; otherwise the acupressure fails. Thus it is effective when the needle is carried through skin, which can be stretched between the points through which the pin or needle passes, but is useless among lax textures, which afford no counter-pressure. The pin must be long enough for its head to lie outside the wound; if a needle be used, it must be straight, and be threaded with wire for the purpose of afterwards withdrawing it.

Acupressure by the twist differs from the first method chiefly in an alteration of direction given to the needle between its first and second insertions, whereby the tissues first pierced are rotated and so stretched. The needle may be carried over or beneath the vessel. Thus, the tissue being pierced in an upward direction parallel to the artery, and the point brought out on one side of it, the direction of the needle is changed by a right angle from parallel to transverse; the point is then, as in the first method, carried over the vessel and fixed on the other side. The rotation of the tissues lifted at the first insertion adds to the pressure of the needle on the artery in proportion as they tend to return to their former place. Or again, the needle, first made to dip across beneath the artery, is rotated with its point upward, and lastly thrust again into the tissues in the direction it takes

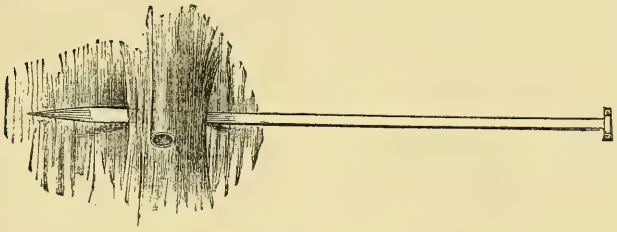
when bleeding stops. This may be at right angles, or even opposite, to the direction in which it was first thrust into the face of the wound. The artery is thus not only compressed, but itself included among the rotated tissues.

Fig. 74.



Second method, over the artery—needle fixed.

Fig. 75.



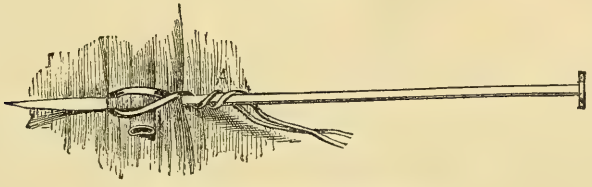
Second method, under the artery—needle introduced.

Fig. 76.

Second method—needle fixed.

By the third method the needle is thrust across under the vessel on the face of the wound, and a fine bent wire, being looped over its point, is made to cross over the vessel, and secured upon the shaft on the part next the eye. Between the two bearings of the wire on the needle the vessel is safely held by very moderate compression. After crossing the vessel, both ends of the wire may be bent together once beneath the shaft of the needle; or, one end being carried on either side of the shaft, they may be crossed beneath it. In releasing the ves-

Fig. 77.

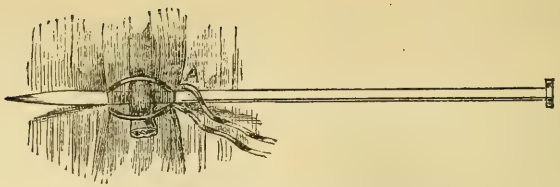


Third method—the ends together at *A*.

sel from this arch or tunnel of wire, the needle must be first withdrawn, when, unless the ends have been drawn with unnecessary force, the wire will lie loose in the wound, and it may be removed.

The *torsion* of arteries is done with clasped forceps, having rather broad points. The bleeding vessel, being to some extent cleared of adjoining textures, is seized longitudinally, and the forceps clasped. Sometimes it is pulled out and held transversely by narrow clasped for-

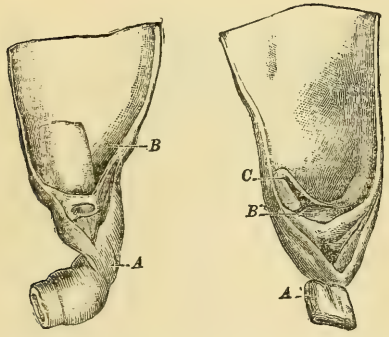
Fig. 78.



Third method—the ends crossed at *A*.

ceps at some distance from the extremity. The instrument inclosing the lower end of the artery is then slowly rotated. By some surgeons the forceps are removed after four complete rotations; by others the twisting is continued until the end of the artery tears off. By either method the outer coat narrows without tearing (Fig. 79), and its pressure cuts the two inner coats at some distance above the part held by the lower forceps. The upper edges of these coats are reverted within the vessel, and the outer coat retains its narrow twisted condition. Hemorrhage is thus prevented, and, while the artery preserves its life, changes of repair go on within the vessel on the same condition as after the ligature, but without any additional process of ulceration or sloughing to cast off the noose. In freeing the wound at the operation itself from every foreign body, torsion has an advantage even over acupressure, but it may be troublesome to perform and it prolongs the operation; it is unsuitable for diseased arteries; and large vessels, even though healthy, cannot be invariably secured by it, Professor Humphry having found in his experiments on animals that the outer coat is sometimes too much weakened by the rotation.

Fig. 79.



Effects of torsion upon an artery, showing the incurvation and laceration of the inner coats. (From paper by Mr. Bryant, Med. Chir. Trans., 1868.)

Transfusion.

When a patient is reduced by hemorrhage to a state of extreme danger, experience may justify the employment of transfusion. Mr. Lane, finding a lad drained of nearly all his blood and on the verge of death, injected into a vein of his arm about five ounces and a half of blood freshly drawn from a healthy young woman. No immediate change followed the injection; but in the course of an hour or two the lad rallied, sat up, and drank water from a cup which he held in his own hand. He had also no return of the hemorrhage.[1] The name of Dr. Blundell is permanently associated with the operation of transfusion, in consequence of his extensive investigations in respect to it, the orderly representation of the facts which he made in his memoir on the subject, and the systematic directions which he gave for the performance of the operation. His conclusions on the subject are too numerous to be given here: the reader who wishes to ascertain them is referred to the Memoir, which may be found at the end of Dr. Ashwell's work on Parturition. The points to be observed in performing the operation are as follows: the transfusion should not be delayed until the patient is *in articulo mortis;* nor should it be on that account declined: human patients have been rallied from that state by means of it, and some animals, even after respiration had ceased. In great emergencies water alone may be injected. If blood be selected, it should be human blood; and it is advisable to take it rather from a man than from a woman, the former being less likely to faint in critical moments. [Milk has been sometimes used, and Dr. Geo. R. Fowler, of New York, has recommended and successfully used in one case an artificially digested animal solution.] An operator familiar with the transfusion apparatus may use it; otherwise he may more promptly rescue his patient with an ordinary syringe, the nozzle of which is fitted to the tubule required for the vein. A vein in the patient's arm is to be fairly exposed by an incision, and opened longitudinally; the arm is then to be bound below the incision, to prevent hemorrhage from below. The syringe, having been made warm, not hot, is to be charged with the blood furnished for transfusion into a tumbler or

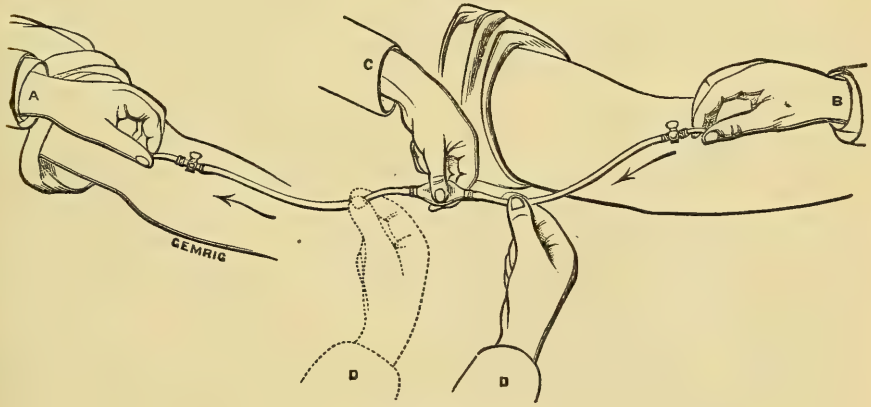
[1] Lancet, 1840, p. 186.

conical receiver: by elevating the nozzle and forcing on the piston all air will necessarily be driven out of the syringe; and the tubule having been inserted into the vein, "without hurry or delay the blood is to be injected in an equable stream." The capacity of the syringe being known, and care being taken to keep the tubule fairly within the vein, there need be no difficulty in determining the quantity of blood which has entered the circulation. The circumstances of the case must determine the surgeon as to the quantity which he will throw in; some adults have not been resuscitated when sixteen ounces of blood were injected; Mr. Lane's boy rallied after receiving five ounces and a half. The state of the blood should be carefully attended to during its flow, as it must be cast away, and warm water passed through the syringe, if any sign of coagulation appear.

[In a recent valuable paper upon transfusion,[1] Dr. T. G. Morton reports nine cases of this operation practised in one hospital, and draws from them confirmation of opinions expressed by him three years previously. His personal experience covers fourteen cases. He says the operation is more frequently successful when employed to remedy excessive loss of blood than under other conditions. He recommends it also in opium poisoning "after all reasonable efforts have been made without any decided improvement," the injection to be preceded by free bloodletting. In cases where the loss of blood is associated with transmitted or direct shock from injury to the nerves, as in railway accidents, it usually proves unavailing. He always uses defibrinated blood, and has shown by experiments upon animals that the introduction of a few clots or a little air is not at all likely to be harmful. The amount of blood injected depends upon circumstances; the larger quantities being used to remedy excessive hemorrhage, the small ones when only a tonic effect is desired.

He performs the *mediate* operation as follows: The blood to be injected is drawn into a conical receiver which forms part of a vessel containing warm water, and is there whipped with small bundles of broom-straw to remove the fibrin. This will require two or three minutes. The blood is then strained through a piece of fine linen into another warm vessel, and replaced in the receiver after the latter has been washed. An assistant does this while the surgeon exposes the vein, ties a ligature tightly below, and places another loosely above the point where the opening is to be made. He then nicks the vein and inserts a steel canula one-sixteenth of an inch in diameter, which is allowed to fill with blood from the vein. A syringe, having a capacity of two ounces, is next filled with blood from the receiver, all air expelled from it, fitted into the canula, and its contents injected very slowly. The injection may be repeated as often as necessary.

Fig. 80.



Aveling's Apparatus.

For the *immediate* operation Dr. Morton recommends Aveling's apparatus, which consists of a small rubber bulb with a tube and canula at each end. After the apparatus has been filled with warm water one canula is placed in a vein of the donor, the other in a vein of the patient, and the blood forced directly from one to the other by pressure on the bulb.

Dr. Howe, of New York, who has done the operation frequently, prefers to use defibrinated blood and an instrument made by Collin, of Paris, consisting of a

[1] Surgery of the Pennsylvania Hospital, 1880.

conical receiver to the bottom of which a syringe and rubber are adjusted in such a manner that the blood can be drawn directly from the bottom of the receiver into the syringe, and then injected into the vein through the tube. It is said to furnish complete protection against the introduction of air. Dr. Howe strains the blood through satin that has been boiled so as to remove all impurities. Non-defibrinated blood can also be used in Collin's instrument.]

Injuries of Vessels.

The effects of injuries of vessels, whether arteries, veins, or capillaries, and the method by which those injuries are repaired, differ essentially according as the skin covering them is broken or entire. From a wound the blood escapes freely outside the body, and is wasted; from a bruise it passes into other torn parts, and is infiltered and pent amongst them. In the opening of large vessels this difference involves the immediate death or safety of the sufferer. It affects only the mode of repair and the liability to subsequent erysipelas and inflammation of the absorbents, when the divided vessels are small; for from these diseases the patient is exempt, so long as the bruised and torn parts and the blood lying amongst them are enclosed by unbroken skin.

Extravasations of blood are limited by its own consolidation in a way which is not possible with urine and the fluid of anasarca. Still it is not uncommon for blood to travel from a bruised spot along a whole extremity, marking its course by a stain of the skin whenever it approaches the surface.

The quantity of blood extravasated in cases of subcutaneous laceration of the tissues is proportioned to the size and number of the bleeding vessels, the force of the circulation in them, and the duration of the hemorrhage; whilst the distance which the blood may travel will partly depend on the quantity thrown out, and the force of its ejection, and partly on the looseness of the structures which it traverses. All these conditions modify the consequences of a laceration of vessels. Thus the firm structures of a healthy adult limit the diffusion of the blood, whilst the emaciated and loose tissues of the aged permit of its oozing through them in so great a quantity that the circulating system and the vital organs may be seriously drained of this important fluid.

Wounds of Arteries.

The state of the integuments becomes a matter of greater importance in proportion to the size of the wounded vessel. If there be an external wound communicating with an opening in an artery, the result is *hemorrhage*. The blood equally escapes from the artery if there be no external wound, but it is then for a time confined within the structures of the part, and constitutes an *aneurism*. The former condition is the subject of the present section; the latter will be treated of in the article on Aneurism.

No parts of the human body appear to escape threatened injury more readily than arteries; none consequently are more difficult to wound. Occupying the least prominent situations in the body and limbs, the principal arterial trunks are exposed to but few of the many accidents which might befall them; and of those injuries which penetrate to their concealed courses, many more are averted by their great elasticity or by the firmness of the outer coat. The difficulty of opening an artery with any but a sharp instrument may be taken advantage of in surgical operations in their neighborhood. Greater safety is secured in exposing an artery about to be tied, if the operator, like Sir Benjamin Brodie, employ a silver knife in opening the sheath; and much of the danger of wounding the obturator artery in the operation for femoral hernia averted by Mr. Skey's practice of slightly blunting the bistoury before dividing Gimbernat's ligament.

The extent to which a large artery is secured from injury by its elasticity is sometimes strikingly shown in military warfare, of which the following may be quoted as examples: "In a soldier of the 56th Regiment, a fragment of shell passed through the ham, between the artery and the bone, without injuring either, although it was much too large to have done so without displacing the vessel. The man afterwards died of diarrhœa. In the 9th Regiment a similar case occurred, but in it a portion of the bone was scooped out by the missile, and the man recovered. In the 47th Regiment a large piece of shell passed through the upper third of the thigh, between the artery and the bone, but injured neither, and recovery took place."[1]

For these reasons wounds of large arteries are of rare occurrence, as compared with those of other soft parts, and with injuries of the bones. Indeed the comparative rarity of these accidents, even in the practice of military surgeons, is remarkable, only fifteen cases having occurred among the 4434 wounded in the Crimea.[2] The fact is, doubtless, partly to

[1] Medical and Surgical History of the British Army which served in Turkey and the Crimea (Parliamentary Blue-Book, 1858), vol. ii., p. 340.

[2] Ibid., vol. ii., p. 257.

be explained by the immediate fatality of the majority of these injuries. Hemorrhage occasions many of the deaths which occur on the field of battle, and keeps out of the records of military surgery almost all the instances of wounds of the arteries of the trunk.

In civil practice, however, the opportunity of ascertaining the duration of life after injuries of the larger arteries can be obtained. No. 1566 in the Pathological Series of the Hunterian Museum is a part of the thoracic aorta of a man, "ruptured transversely through all its coats, and round nearly five-sixths of its circumference. He was supposed to have lived ten minutes after a wagon passed over his body." In the same series of the Museum of the Middlesex Hospital is the lower part of an abdominal aorta cut half across by a pistol-bullet. The man was under the care of my colleague, Mr. Shaw, who ascertained that he survived the injury for an hour and a quarter.[1] A woman lately died in St. Bartholomew's Hospital, one hour after her aorta had been punctured with a needle accidentally driven into the chest. The wound of the artery opened into the pericardium, and the patient died of compression of the heart by the blood which escaped into that cavity.

No. 1565[a] in the Hunterian Museum illustrates, however, so remarkable a fact that it may be related at large. The specimen consists of the ascending aorta of a man, containing a jagged mass of skin and subcutaneous tissue, and a hemispherical socket of lymph, which adheres to the interior of the wall of the aorta, and which lodged a spherical bullet. The piece of skin lies against the left wall of the ascending aorta about an inch above the valves; the socket of lymph is fixed to the wall of the artery immediately beyond the skin. The rest of the artery is healthy. The account of the case, given by Mr. Brunton, Assistant Surgeon on board the hospital ship in the Mediterranean, and communicated by Sir Stephen L. Hammick, is to the effect that a boat's crew, detached to cut out a vessel, met with determined resistance; amongst the wounded was "a seaman, who affirmed that a musket-ball, striking his oar, had run along it and entered his side. He lost a good deal of blood at the time, and then almost completing the third day from the injury, died.

"The post-mortem examination showed that a wound was made between the eighth and ninth ribs, and passed through the diaphragm into the pericardium, which was found full of blood, and the hole made by the shot closed up by firm coagulum. Much blood had escaped into the chest and abdomen, not only from the course of the ball, but also from the heart itself."

An open wound of the carotid or femoral artery may destroy life in a few seconds; this man having a large aperture in his ascending aorta, partially plugged by a foreign body, lived nearly three days.

The injuries which require the attention of the surgeon are almost exclusively those of the neck, the head, and the extremities. They may be thus arranged:

1. An artery may be seriously injured by a violent blow, although it presents no trace of laceration of any of its coats. The only consequence of the injury is a narrowing of the calibre of the stricken part of the vessel; but that narrowing is permanent, and may seriously impede the current of blood to distant parts of the limb. It is probably not sufficient of itself to occasion gangrene, but it will concur with other injuries, in themselves also insufficient, to produce that result.

"P. R., aged 21, was wounded on June 8 by the explosion of a shell, which produced a lacerated wound of the inner ankle of the left leg, laid open the joint, and exposed, but did not fracture, the tibia. He had also received a second wound, by what was supposed to have been a canister shot, through the upper part of the thigh of the same side, in the course of the vessels, neither of which, however, appeared to have been wounded. On June 16 incipient gangrene of the foot had set in, but the system was but little affected by it. The limb was amputated immediately below the knee by a small anterior, and large posterior flap, and the stump lightly dressed. On the 18th symptoms of gangrene appeared in the stump, showing themselves first in the posterior, and then extending to the anterior flap. On the 19th the gangrenous inflammation showed some inclination to stop immediately below the wound in the thigh on the inner side, but it had extended on the outer too high to allow of anything short of amputation at the hip-joint. On the 20th it reached the walls of the belly, and the patient died at 2 P. M. on that day.

"On a post-mortem examination of the body, the ball was found to have passed through the thigh internally to the sheath of the femoral vessels, which it had grazed but not opened. The artery at this point was slightly contracted for about an inch of its length, but pervious; it contained no coagulum, and beyond the contraction showed no marks of inflammation. The vein, however, was not only slightly contracted, but its internal surface was inflamed and filled with partially organized lymph, as far upwards as the entrance of the deep iliac vein, and downwards for about two inches from the wound. Its course was thus entirely sealed."[1]

The contractility of arteries exerts a most important influence upon their injuries, as well as on their functions. Not only do these vessels adapt their calibre

[1] Transactions of the Pathological Society of London, vol. x., p. 168.

[1] Surgical History of the British Army, etc., vol. ii., p. 343.

from time to time to the size of the stream which passes through them; but under extraordinary circumstances they nearly, or even completely, close. The arterial trunk in an amputated limb may be seen to have contracted to one half of its former area, if examined a few minutes after the operation. John Hunter saw the carotid artery of a living ass diminish in size upon its mere exposure to the air. The same power permanently reduces the calibre of a tied artery between the ligature and the next branch above it, and the contraction in that case takes place, whether the unused part of the artery still pulsate with fluid blood or be filled with coagulum. The possible rapidity of this contraction and its extent are well seen at the extremity of an artery cut directly across, the stream of blood from which gradually lessens, and at length ceases, as the coats of the vessel approximate and close its orifice.

These instances are unquestionably vital contractions of the artery, effected probably by its middle coat, and are not due to inflammation. They occur sometimes too rapidly to be attributable to that disease, and are unaccompanied with any other indication of it. Moreover, an inflamed artery, if altered at all in its calibre, becomes rather dilated.[1] Its area might be intruded on or compressed by inflammatory products, but the artery itself would not contract. Both conditions, of vital contraction and inflammation, may, as in the following instances, be combined together as results of the same injury.

A ball passed between the popliteal artery and vein of a soldier without opening either, and gangrene of the limb destroyed life on the sixteenth day. The vein was found blocked with coagulum. The coats "of the artery were not destroyed in substance, although bruised; it was at this spot much contracted in size, and filled above and below by coagula."[2]

A similar occurrence was observed in the Crimea,[3] where, when sloughing had attacked a large wound of the arm, occasioned by a fragment of an exploded shell, arterial hemorrhage took place, and it was found that the brachial artery had sloughed to the extent of one-eighth of an inch of its length and one-third of its circumference. In the operation of placing and tying a double ligature above and below its bleeding aperture, the vessel was found to be so much smaller than usual that a high division of it was suspected. It had, however, contracted in the vicinity of the injury and slough.

In all the remaining examples of injuries of arteries, one or more of the coats, or parts of the coats, of the vessels have been found to be divided: the varieties of these accidents are numerous, and they entail such various consequences that they must be separately related.

2. Considerable violence sometimes lacerates the inner coats of an artery, without tearing through the stronger outer coat. Neither in this injury, nor in that last described, is there any hemorrhage from the vessel; the consequences of the injury develop themselves, at a later period of the case, in mortification, or other result of a deficiency of arterial blood in the parts beyond. In the examples of this injury which have fallen under my observation, the inner coats have been separated from the cellular around their whole circumference and for some distance in their length, and inverted within the artery so as almost or completely to block up its lower and uninjured part. As the lacerated coats adhere by what before inversion was their *lower* margin, their separation from the outer coat is probably not the immediate effect of the injury, but occurs afterwards from the force of the arterial current. And the phenomena observed in the so-called "dissecting" aneurism support this suggestion. The inner coats are in that accident sometimes separated from the outer throughout all the large arteries of the trunk; and Rokitansky describes one instance in which a portion of the inner coats of the arch of the aorta was driven onward in the course of the arterial current, and lay rolled up into a tube, within the left subclavian artery.

A man was admitted into the Middlesex Hospital under the care of Mr. Shaw, and lived three hours after having been struck by the shaft of a vehicle in the right iliac region. The external injury was slight, but the lower limb of that side was without pulsation, motion, or sensation. On examining the vessels, a rent of an inch in length was discovered in the inferior vena cava, and the inner coats of the right common iliac artery were partially detached from the outer, and inverted downwards.

In another man, brought into the Middlesex Hospital, under my care, who survived a severe injury of his thigh, and incipient gangrene, about fourteen hours, three inches of the popliteal artery and vein were separated from the other soft parts, and both vessels for the same distance were blocked with coagulum. A part of the coagulum adhered to the artery, and at that spot the internal coats, in

[1] Rokitansky, Path. Anat., Syd. Soc., vol. iii., p. 254.

[2] Guthrie, On Wounds and Injuries of the Arteries, 1846, p. 22, Case 24.

[3] Surgical History of the British Army, etc., vol. ii., p. 342.

their entire circumference, had been torn through, separated for three-fourths of an inch from the outer coat, and turned down within the lower part of the vessel, the canal of which was thus completely plugged. The external coat of the artery was entire, though slightly ecchymosed.

Division of the two inner coats and obliteration of the canal is the amount of injury aimed at in *applying a ligature upon an artery*. The earlier operations of this nature were attended with an amount of violence to the artery, hardly less than that described in the last case. The vessel was forcibly and extensively separated from its sheath, and unnecessarily lacerated with clumsy tapes and instruments. [This statement is not entirely accurate. Hunter, in his first operation, placed four tape ligatures upon the vessel at a distance from each other, avoiding laceration of the inner coats, and hoping to close the vessel by what he terms "adhesive inflammation," provoked by the temporary pressure of the ligature on its outside.] Modern surgeons disconnect the artery as little as possible from its sheath, tie it with a slender and firm ligature, and find the consequent mortality much reduced. The following are the conditions of failure and success in the operation, so far as regards the artery and its collateral branches.

The ligature, when well applied, cuts the two inner coats, tightly constricts the outer coat, and stops the current of blood along the vessel. Within a few hours after the operation, there forms above the ligature a coagulum of blood, which usually fills the entire calibre of the tube, and adheres to the lacerated surface within it. Being disturbed at its upper part, however, by the arterial impulse, which alternately lengthens and shortens the vessel, the coagulum is there less complete, and narrows to a point. It varies much in length, and therefore in form, in different cases. It may not adhere anywhere, even by its lower end. It may not exist at all, and is not unfrequently absent from the portion of the artery which is below the ligature. I have, however, found the iliac artery filled with coagulum, to either extremity, after ligature at the middle of its course. That the plug is not without advantage is manifest, since it secures repose to the artery at the part which has been tied; and if the ligature be removed before the consolidation of that part, the permanent plugging of the artery must in great degree be due to the coagulum.[1] That the plug, at the same time, is not indispensable for the closure of the vessel, appears from that process being sometimes perfected without one. Contraction of the artery also takes place, chiefly above the ligature. Below the ligature the artery sometimes presents neither contraction nor clot.

The efficient process, by which the artery is eventually closed, meanwhile goes on at the tied portion. The inflammation set up by the operation and by the presence of the ligature occasions an effusion of plastic lymph, which coheres within the vessel with the lacerated coats, and externally accumulates around the artery and along its sheath. Penetrating also the very substance of the external coat next the ligature, it unites that coat with itself into one consolidating mass. From the outer side of this mass the vessel severs by ulceration, or casts off by sloughing, the constricted part of its external coat. The separation of this leaves the vessel divided, yet with each extremity firmly sealed, even when unprotected above by a conical clot. The final changes in the artery are the obliteration of its canal from the closed extremities to the next pervious lateral branches, and the conversion of its tissue into a fibroid cord. When an internal plug is present, it probably takes part in producing the former of these changes, and adheres, by the intervention of a new albuminous material formed from the blood, with the original lining membrane of the artery. The contraction and final conversion of the coats into a fibroid cord follow yet more slowly upon the cessation of the function of the artery.

The process just described is liable to failure in various ways, which most commonly shows itself by *hemorrhage* at the seat of operation about the time of the separation of the ligature. There appear to be three modes in which hemorrhage is brought about: a partial or entire absence of contraction of the artery, a defect in the quantity or plastic character of the lymph, and ulceration of some part of the vessel. The first only is of local origin; the last two depend upon constitutional causes, or both perhaps upon the same cause. It will be seen, by referring to the remarks on ATHEROMA of the arteries, that vessels in that condition are incapable of contraction. The ligatured part of such an artery is consequently exposed to the full force of the current of blood, and needs for its security what rarely coincides with such disease, viz., a very vigorous process of repair. When the ligature becomes loosened from such an artery, the blood bursts through the weak barrier at its extremity, and not uncommonly a fatal result follows the disaster. That the absence of this contraction has something to do with the occurrence of hemorrhage from a tied

[1] Med.-Chir. Trans., vol. ix., p. 405.

artery is rendered further probable by the fact, that both are most frequently observed below the ligature. The other causes of hemorrhage appear to be constitutional. Arteries may be found in museums with but a very small and inadequate quantity of lymph about the ligature. It has been formed in very small quantity, or, having formed, has failed to become organized and to consolidate. When the ligature loosens, the extremity of the vessel is found to be unclosed. In some of these specimens it is difficult to be certain whether the ragged orifice, through which the fatal hemorrhage occurred, was a laceration by the force of the blood, or an ulceration which, in loosening the ligature, also opened the artery.

The presence of a clot may be of importance in any artery; in the larger it seems to be indispensable. Small arteries scarcely ever bleed after ligature, whereas in the innominate the process of repair has never been known to be accomplished. [Smyth, of New Orleans, tied the innominate and common carotid successfully in a case of traumatic aneurism of the subclavian artery.] But hemorrhage at the seat of ligature does not altogether, or chiefly, arise from the large calibre of the artery; it is also in part determined by the proximity of collateral branches to the ligature. [The importance of this fact has been much diminished by the introduction of the catgut ligature and the antiseptic method.] On comparing the common carotid or external iliac arteries, vessels which run a long course without giving off branches, with arteries in the opposite condition, such as the common femoral, the advantage in respect to secondary hemorrhages is found to be greatly on the side of the former. The artery gives way in 6½ per cent. of the operations on the first vessel, and in 6 per cent. of those on the external iliac, while the frequency of that event in the instance of the common femoral mounts up to 56 per cent.[1] [A very different result has followed ligation of the external carotid, the branches of which are numerous and closely placed. In 24 cases collected by Guyon,[2] secondary hemorrhage occurred only once.]

[The operative methods of ligating an artery in continuity have been greatly modified by the successful introduction of animal ligatures and the antiseptic treatment of wounds, and our knowledge of the histological processes by which an artery thus occluded becomes permanently closed has recently become much more accurate and complete.

When a ligature is applied to an artery with sufficient force to divide, or perhaps to merely bruise, its inner coat, the traumatism is followed promptly by proliferation of the cellular elements of the intima at the point of injury and for a variable distance on either side. This proliferation results in the production of granulations which develop into a mass of fully formed connective tissue, which, when all goes well, permanently and effectually plugs the vessel. If, as is supposed to be usually, but not always, the case, a clot forms in the adjoining portion of the vessel immediately after the application of the ligature, some of the granulations make their way into it in the form of delicate, interlacing fibres, which have been thought by some observers to be formed by the cellular elements of the clot itself, and have thus given support to the theory of "organization of a clot." This process of cicatrization of a vessel is exposed to the same accidents and failures that may happen to cicatrization elsewhere. If the irritation is too great, if the condition of the patient is unfavorable, the granulations may form or develop too slowly, free suppuration and ulceration taking the place of prompt cicatrization, and then secondary hemorrhage is inevitable unless the vessel is closed by a firm clot.

A clot does not always occupy the artery between the ligature and the nearest collateral branch on the proximal side; there are many cases on record which prove the contrary. Mr. Holmes tied the subclavian in its third portion with a catgut ligature, and found at the autopsy, some time afterwards, that the vessel was unobstructed, except by a sort of diaphragm about one-eighth of an inch in thickness, which closed it completely at the point where the ligature had been placed. In a personal case, the popliteal artery, examined three months after amputation through the condyles of the femur, at which time its divided end had been secured by a carbolized silk ligature, both ends of which were cut short, was patent to within one-eighth of an inch of the ligature, and contained no clot, although much narrowed and shrunken; and in a case where Dr. Keyes tied the same vessel in continuity, it was found entirely empty when examined after death on the third day.

When the ligature is made of a material whose presence will not be tolerated by the tissues, and which must therefore be cast off by the sloughing of the tissues contained within its loop, the probability of an accident is greater, because of the

[1] Porta, Delle Alterazioni patologiche delle Arterie, 1845, p. 136. Broca, Des Anévrismes, p. 604.

[2] Mém. de la Soc. de Chirurgie, 1864, p. 555.]

irritation caused by its presence and of the necessity for keeping the external wound open. The knowledge of this fact has led to many of the modifications of the ligature or substitutes for it mentioned above, and, also, within the last few years, to one other, which is now very generally employed, the antiseptic catgut ligature.

The use of a ligature composed of fleshy animal tissue, in the hope that it would either be absorbed, or, if retained, would not excite suppuration, is not of very recent origin. More than fifty years ago, Wardrop, adopting the suggestion of an Edinburgh surgeon, tied the carotid artery with a ligature made of silk-worm gut, cut both ends short, and got primary union of the wound, but it is only since the introduction of Mr. Lister's antiseptic method that the use of the catgut ligature has become general. Experience has shown that the presence of carbolized catgut is perfectly tolerated by the tissues, especially if the wound is treated antiseptically; it does not provoke suppuration, but softens and becomes absorbed, giving place to cicatricial tissue. A similar result may be obtained with carbolized silk or hemp, or with silver wire, but not so certainly, and the general practice at present, therefore, is to use a catgut ligature for tying an artery, either in continuity or after division.

The catgut is prepared by soaking it for a long time in carbolized oil. Some surgeons, fearing lest the ligature may soften too promptly after its application, harden it by maceration in a solution of chromic acid (three grains of the acid in an ounce of glycerine is recommended by Prof. Agnew), and then place it in the oil, where it must be kept for two weeks, and may then be allowed to remain until wanted. An excellent size for the ligation of a large artery is that of the violin string known as "E, No. 70." For the small vessels divided in the course of an operation ligatures of much less thickness are sufficient.

It is thought by some that the ligature should not be applied with sufficient force to divide the inner coats of the vessel. They maintain that if the ligature is made tough enough to resist the solvent action of the juices of the part for several days, a fibrous band will form about it, take its place, and permanently perform its temporary function of preventing the flow of blood through the vessel, and that in this manner the object of the operation is obtained without the risks incidental to a partial division of the wall of the artery. Mr. Barwell employs with this object narrow flat ligatures made of longitudinal strips of the aorta of an ox, and draws them just tightly enough to arrest pulsation, having found that a tractile force of three pounds applied to a round ligature is sufficient to divide both the inner and middle coats.

Theoretically, this view seems to be correct, but there are serious practical difficulties in the way of its application. The proper degree of toughness cannot be certainly given to the ligature, and if it is too tough, or even, perhaps, if only tough enough, it may act as a foreign body; while if it is too soft, the vessel regains its patency. In the latter case the object of the operation is defeated, in the former, secondary hemorrhage is almost inevitable, for the vessel is opened by the sloughing, which is nature's means of throwing off the foreign body—risks which are certainly greater than those which experience has shown to follow division of the inner coats by a catgut ligature. I know of two cases in which catgut ligature was applied to a large artery without dividing its coats. In one a single ligature was passed twice about the carotid and then tied to arrest hemorrhage from some point in the distribution of the vessel. The bleeding soon recurred with a fatal result, and at the autopsy the carotid showed no trace of the ligature. In the other case a thick double ligature was applied to the femoral for the cure of a popliteal aneurism. Pulsation returned in the artery below the ligature after a short time, and at the autopsy, a month or two afterwards, the artery was found patent throughout. I do not know how much force was used in the first case, but in the latter the knot was firmly drawn, and the failure to divide the coat was probably due to the fact that the ligature, being double, acted as a band rather than as a cord.

Occasionally a catgut ligature, prepared in the most careful manner, has proved insoluble, and has been cast out by suppuration, but the chance of secondary hemorrhage has been so reduced by the use of this material, together with antiseptic precautions, that Mr. Lister has expressed publicly his belief that a ligature could thus be safely applied, even to the innominate artery.]

[Mr. Lister has lately insisted especially upon the importance of properly seasoning the catgut, and of using a mixture of one part chromic acid, 4000 parts water, and 200 parts of pure carbolic acid, for steeping it. In this he prepares a quantity of catgut equal in weight to the carbolic acid.—P.[1]]

The laceration of the inner coats of an artery, instead of being repaired, is sometimes followed by the formation of an *aneurism*. Possibly many aneurisms, which are attributed to previous injuries,

[1] Med. Times and Gaz., Feb. 5, 1881.]

arise in this manner, though the subsequent changes at the part obscure their mode of origin. Though a rare, it is an occasional event after the laceration by ligature. In a case reported by M. Delacour,[1] of Rennes, an aneurism formed on the anterior tibial artery after an amputation for compound fracture of the leg, and could be seen enlarging on the face of the stump. Repeated hemorrhages took place from it between the thirteenth and thirty-eighth day after the amputation, which were arrested on the latter day by the ligature of the femoral artery. The patient eventually recovered, though not without hemorrhage from the wound of the operation in the thigh, as there had previously been from the wound at the fracture. Warner, in his Cases of Surgery (p. 50), mentions a yet more remarkable instance of this occurrence. An aneurism of the brachial artery formed in the stump of an arm which he had amputated a few days before. He applied a ligature upon the vessel "above the upper extremity of its distended coats," and cured the aneurism; but a second aneurism formed above this ligature. A third operation was followed by the appearance of a third aneurism in the same relation to the ligature, for which he tied the artery again; but as on this occasion he performed Hunter's operation, not Anel's, tying the artery near to the axilla, he succeeded in saving his patient. No doubt, in these cases there existed a previous disease of the coats of the arteries in the situations selected for the ligatures.

The injuries of large arteries under our present consideration are rarely uncomplicated. Most commonly the adjoining vein is wounded or bruised at the same time as the artery, and the sudden or even the gradual stopping of its circulation which ensues, almost necessitates *gangrene* of the limb.[2] Nerves, as well as other soft parts, may also be torn or bruised, and either numbness or painful exaltation of the function of the nerves may follow their injury. Broca[1] mentions an instance of the latter kind as *inflammation of a nerve*, occurring consecutively upon an operation for tying an artery. The symptoms commenced nineteen days after the brachial had been tied at five fingers' breadth above a traumatic aneurismal varix in the bend of the arm. The first indications of the neuritis were, painful sensations in the forearm and hand, which were succeeded by sharp pains in the three and a half fingers supplied by the median nerve. The pains were increased by pressure on the wound, but not on the fingers. They diminished in five days, and were followed by numbness, and at length by almost complete loss of feeling, in precisely the situation which had previously been painful. In ten days more the natural sensibility had returned. Phlebitis and fatal pyæmia are more common results of the operation of tying an artery.

The effects of obstruction of arteries upon the parts of the body which they supply with blood have already been partly stated. Upon a sudden obliteration of the principal artery of an extremity, more or less gangrene may ensue. The safety of the limb in this respect depends upon the re-establishing of the arterial circulation through the enlargement of the collateral channels. Gangrene is a less frequent result of the obliteration of the artery in the shorter and more vigorously nourished upper limb than in the lower. It is also more apt to occur when particular portions of the main artery are obstructed. Thus a ligature or wound of the common femoral is more often followed by the death of the leg, not only than when the same trunk is blocked up below the origin of the profunda, but than when the external iliac is obstructed. For the collateral circulation is insufficient to keep the limb alive without the aid of the epigastric and circumflex ilii arteries. A similar, but a less serious, deficiency of collateral vessels is met with at the upper part of the brachial artery. In all cases of wounds in the neighborhood of large arteries, the attention of the surgeon will of course be directed to the state of the circulation. If the pulse have ceased beyond the injured part, the limb will become cold and pale, and care must be given to keep it warm, and to avoid all bandaging and malposition by which the establishment of the collateral circulation might be interfered with. The appearance of heat and redness on the integu-

[1] Broca, Des Anévrismes, p. 39.

[2] At the Westminster Hospital, twelve days after the infliction of a punctured wound on a man's thigh, Mr. Holthouse cut down, and found the femoral artery opened in Hunter's canal. He tied both ends of the vessel. At the same time venous blood escaped in great quantity from a large vein adjoining the artery. This hemorrhage was arrested by plugging; and, after the sloughing of a small portion of skin on the outside of the foot, the man recovered. Eight months later Mr. Holthouse found the limb useful, the tibial artery beating on the foot, and the internal and external saphena veins swollen. In the absence of further evidence, this case may be regarded as probably one in which a contemporaneous obliteration of the femoral artery and vein was not followed by gangrene of the limb.—British Med. Journ., 1859, pp. 364, 954.

[1] Des Anévrismes, p. 479.

ments may be hailed as a sign that the blood is traversing the smaller vessels towards the distant parts of the limb; whilst increasing coldness of its surface, a mottled appearance, delay in the return of blood to a part which has been emptied of it by pressure, slowness in the refilling of superficial veins after the blood has been carried along them by the finger, or in their filling when compressed at the higher parts of the limb, all indicate a languid state of the circulation and imminent mortification.

Even when the collateral circulation acquires a vigor and amount sufficient to insure the life of the limb, it is rarely the case that the latter regains its powers in all respects. A limb in which the principal artery is obliterated generally remains for years in a state of feebleness and impaired nutrition. It is weaker and, unless it be œdematous, smaller than its fellow; it is easily chilled, and may be permanently colder than natural. The sudden loss of the artery is sometimes never repaired by the establishment of a vigorous collateral circulation, and the limb, though not dead, remains little capable of muscular exertion, emaciated, cold, and with its integuments dry and shrivelled. But if the smaller arteries have enlarged before the obliteration of the main trunk, as is usually the case when an aneurism has existed for some weeks or months before the ligation of the vessel leading to it and to the limb, the latter may regain much of its healthy powers. I tied the superficial femoral artery for an aneurism which had been known to exist in the ham for eight weeks, and had that morning burst into the knee-joint. Thirteen weeks after the operation, the man was able to walk from Hampstead to the Middlesex Hospital; the leg and foot were œdematous, and the whole limb, below the site of the operation, larger than its fellow. I examined the lower limb of a healthy man, in whom the same artery had been tied by Mr. Quain nine years before. The circulation was so far re-established that the anterior tibial artery could be felt beating on the instep. Yet the ankle was œdematous, and the posterior tibial could not be felt. The whole limb was smaller and weaker than the other, and liable to become cold. The foot was bent inwards as in slight club-foot, and the integuments were dry and scurfy.

3. There remains one other mode in which an artery has been known to be injured without the entire division of all its coats. It is that in which the vessel is cut or torn through its external, and more or less of its middle coats, whilst a thin, undivided inner portion still preserves the integrity of the canal. No hemorrhage takes place at the time of such an accident. In experiments on animals, a great portion of the coats of an artery may be dissected off, and the extremely thin membrane which remains will bear, without tearing, the impulse of the arterial current within, and also firmly heal over.[1] A result so favorable does not, however, follow the same kind of injury in the human subject, and it is right to tie an arterial trunk so wounded at the time of the accident, though there be no hemorrhage to indicate the necessity of so doing.[2]

4. A gush of blood issues from a recent wound. Bystanders fly hither and thither for bandages, but leave the life-blood to escape. If a surgeon is at hand, he instantly puts his finger on the bleeding point and stops the flow. Whence comes the blood? From a vein or an artery? From a large or small artery? From a wound of the vessel which is, or is not, capable of closing spontaneously? How is the flow to be stopped? Must the artery be tied? If so, where may the ligature be applied upon it? Is one ligature sufficient? Are two enough? Further questions arise as to the best direction in which incisions may be made, and on other proceedings required by the special circumstances of the injury, in the operation of tying the vessel.

Both caution and experience are necessary in estimating hemorrhage. All persons are apt to be misled by its violence and rapidity into attributing the bleeding to a larger vessel than has actually been wounded: it is even possible for a moment, when bleeding has ceased, to mistake for present hemorrhage the mere overflow of blood which is pressed out of a wound by some movement or handling of the injured part. However abundant may be the hemorrhage from a vein, the color and steady current of the blood at once distinguish it, and it is readily controlled. The numberless small vessels of a large recently cut surface bleed smartly; the even current and dark tint of the blood, however, cannot be confounded with its bright color and jetting flow when an artery of considerable size has been wounded. More difficulty is experienced in determining the force of the bleeding when it is clearly arterial. That which is relatively a large wound in an artery of moderate size, may furnish a hemorrhage indistinguishable from that of a main trunk in which a comparatively small

[1] Transactions of a Society for the Improvement of Medical and Chirurgical Knowledge, vol. i., p. 144.

[2] Guthrie, Wounds and Injuries of Arteries, 1846, p. 78, Case 123.

opening has been made. The perplexity is the greater as the wound approaches the known situation of a great artery. For small arteries divided near or at their origins from large trunks bleed with a severity quite disproportioned to their size, and wounds of them have been mistaken for wounds of a trunk-vessel.

When the surgeon is satisfied that the bleeding from a deep wound is arterial, it is not indispensable that he should tie the vessel. The smaller arteries are much more numerous than the larger, and, in the great majority of cases, even arterial hemorrhage ceases without the application of a ligature. The flowing blood coagulates around and upon the orifice of the vessel, which then heals. Some wounds of even a large artery may close, but it is impossible to depend upon their doing so spontaneously. Many lancet-wounds of the brachial artery, for instance, heal under pressure. Mr. Guthrie mentions the case of a wound made by a pike in the axillary artery which healed without surgical interference. The life of Larrey's patient, Pierre Cadrieux, appears to have been saved by the singular circumstance, that the subclavian vein was also pierced by the lance which wounded the artery. The blood from the latter vessel, when restrained from passing through the external wound, escaped into the vein, and was thus saved to the system until the wound healed.[1]

Such cases as the following may illustrate the occurrence of hemorrhage, controllable without the application of a ligature, as well as some of the means which may be adopted in similar circumstances to stop it.

"An officer, aged twenty-eight, was struck by a musket-bullet in the back of the neck. It entered near the median line, passed upwards and to the left, and was cut out immediately below the zygomatic angle of the malar bone. There was considerable pain on moving the jaw; and on introducing the finger into the mouth, the teeth were found to be irregular and loosened. The ramus of the jaw, or its condyloid process, appeared to have been injured, and probably the zygomatic process of the temporal bone. No untoward symptom occurred until the twelfth night, when he awoke from sleep, and found himself bleeding from the wound in the nape of the neck. After about six ounces of arterial blood had been lost, the hemorrhage ceased spontaneously. A recurrence of bleeding to nearly the same amount took place thrice within the next three days. The blood seemed to well up from a deep source, and was restrained by a very little pressure. As oozing continued, the wound in the nape of the neck was plugged with lint steeped in tincture of matico, and bandaged. Occasional oozing from the wound in the cheek continued during the day. Sumat plumbi acet. gr. jss. c. opii pulv. gr. ss. tertiâ quâque horâ. From this time the bleeding is said to have ceased."[1]

"A private soldier, aged twenty-six, was struck by a grape-shot, which split his cheek extensively, fractured the superior maxillary bone, and lodged in front of the vertebræ. A portion of the superior maxillary bone, with all the molar teeth and palatine plate, were displaced into the mouth, and found to be lying on the tongue, preventing the patient from closing his mouth. The powers of deglutition and articulation were completely gone, respiration was seriously impeded, and saliva mixed with blood flowed from the mouth. The wound in the cheek was enlarged, the displaced bones, and portions of the malar bone, floor of the orbit, and ascending process of the superior maxillary bone were removed, and the ball extracted, the vast wound lightly plugged, and the parts brought together. No bad symptom came on until the morning of the fourth day, when secondary hemorrhage to some extent occurred from the back of the palate. On removing the lint and the clot of blood, no bleeding vessel could be detected. The wound was again plugged with lint dipped in tincture of matico, and ice was kept applied to the palate. Whenever the ice was removed, hemorrhage returned, and it was therefore kept constantly renewed for six hours. The bleeding returned when he attempted to take food, and it was again checked with ice. After this he recovered."[2]

"A musket-ball entered immediately behind the trochanter major of a soldier, passed downwards, forwards, and inwards, and came out on the inside of the anterior part of the thigh. The ball could not have injured the femoral artery, although it might readily have divided some branch of the profunda. Several days after the receipt of the injury, I saw this man sitting at night on his bed, which was on the floor, with his leg bent and out of it, another holding a candle, and a third catching the blood which flowed from the wound, and which had half filled a large pewter-basin. They seemed to think it would stop in due time, having bled once before during the afternoon. I placed a tourniquet, with a thick pad, as high as possible on the upper part of the thigh, and requested the officer on duty to loosen it in the course of an hour; which was done, and the bleeding did not recommence. The next day I placed the patient on the operating-table, removed the coagula from both openings, and tried to bring on the bleeding by pressure and by moving the limb; it would not, however, bleed. As there could be no other guide to the wounded artery, which was evidently a deep-seated one, I did not like to cut down into the thigh without it, and the man was

[1] Larrey, Clinique Chirurgicale, vol. iii., p. 139.

[1] Surgical History of the British Army, etc., vol. ii., p. 307.

[2] Surgical History of the British Army, etc., vol. ii., p. 306.

replaced in bed, and a loose precautionary tourniquet applied. At night the wound bled smartly again, and the blood was evidently arterial. It was soon arrested by pressure. The next day I placed him on the operating-table again, but the artery would not bleed. This occurred a third time, and with the same result. The bleedings were, however, now almost immediately suppressed, whenever they took place, by the orderly who attended upon him, care having been taken to have a long thick pad always lying over the femoral artery, from and below Poupart's ligament, upon which he made pressure with his hand for a short time. The hemorrhage at last ceased without further interference, and the man recovered."[1]

It is clear from these and many other cases that hemorrhage, even of an alarming character, may cease; and the rule generally followed amongst surgeons in early and doubtful cases is to employ graduated pressure, cold, astringents, or an elevated posture, as may be most suitable in the circumstances; and to assist these various direct means, when practicable, by the addition of indirect compression. It may be said that all completely divided arteries, not being trunk-vessels, if they are accessible to these modes of treatment, may be closed. But when bleeding is severe, it may be doubted whether such treatment, though capable of effecting a cure, be, after all, preferable to the ligature; and, if the vessel be easily accessible, few surgeons would hesitate to tie it. It is to be remembered that the bleeding may be renewed, that the soft parts which are subjected to pressure may slough, and that by inflammation they will become matted together, and for a time, or permanently, useless. The consequences in the palm of the hand, for example, are serious. Moreover, though the wound be capable of spontaneous closure, no eventual advantage is gained by the risk of trusting the wound to it, since equally as by the ligature the artery becomes obliterated.

When hemorrhage recurs after having once ceased, the surgeon will judge by its severity, both absolutely and comparatively with the first bleeding, as to the propriety of cutting down and tying the artery. The operation at this period is likely to be more difficult than at first, in consequence of the changes which have meanwhile occurred in the parts concerned. For the same reason, the bleeding is less likely to stop than it was at first; and, whilst a cure may possibly be obtained, it is again better practice to secure the vessel by operation. An incised wound entails less mischief than one around which the tissues are consolidated by the action of pressure and astringents; to say nothing of the freedom from mental disquietude enjoyed by both patient and surgeon, and the security against further loss of blood, afforded by the ligature.

Hemorrhage is sometimes quite disproportionate to the size of the bleeding orifice, or at any rate to our estimate of its importance. It is severe in persons who have stiff arteries and a hypertrophied heart. Mr. Guthrie mentions that he has, more than once, known the femoral artery, punctured by a tenaculum in an amputation, to bleed so uncontrollably as to require a ligature. More seriously it has happened that, the power of an artery to bleed having been misapprehended, a trunk-vessel has been needlessly tied. Thus the external iliac artery has been tied for a wound of a small and superficial branch of the femoral artery.

There are certain wounds of arteries which are probably always incurable by local processes of repair, however aided. Hemorrhage cannot finally cease so long as any foreign body remains in the opening of the artery, and a fatal result may ensue upon the failure to extract it. A fragment of tobacco-pipe, entering by the mouth, pierced the anterior pillar of the fauces, on the right side, and lodged. Hemorrhage took place at the time, but stopped of itself; and I saw the young man, six or seven hours afterwards, pale, and with one tonsil swollen near the wound. No fragment of pipe could be seen or felt, or detected in the wound with a probe. A large swelling formed in the upper half of the neck, which on the seventh day suddenly began to pulsate, while arterial blood issued copiously from the mouth. The carotid was tied below the swelling. The operation was immediately followed by paralysis of the left extremities, and it persisted. On the thirteenth day after the accident, bleeding suddenly recurred through the mouth, and was immediately fatal. At the post-mortem examination, the lower end of the fragment of pipe was found lying in a hole at the top of the common carotid, surrounded with buff-colored lymph, and with a carotid branch on either side of it. The wound of the vessel could not possibly have closed. Although the primitive carotid was filled with clot from near the wound down to the ligature, the external and internal carotids were empty. There were also several fetid abscesses in the right hemisphere of the cerebrum. Mr. Vincent, in publishing this case in the twenty-ninth volume of the Medico-Chirurgical Transactions, remarked that, if the piece of pipe had been discovered and extracted through the mouth, fatal hemorrhage would in all

[1] Guthrie, On Arteries, 1846, p. 69.

probability have occurred, as he believed to have happened in a previous and similar case.

Neither does an artery heal when the wound in it, whether longitudinal or transverse, is an extensive one. When there is a long rent in an artery, or a division of it half across, its retractile and contractile powers tend to keep open and enlarge the wound both in length and breadth. Neither the upper nor the lower end of an artery so wounded can completely contract; no fibrinous plug closes the wound itself; and if the artery be large, or if it lie in loose tissues, which afford no support to the amount of pressure requisite for its obliteration, the bleeding may be fatal. The temporal artery thus wounded may be as safely treated by a firm compress as by the division of the vessel. The following case was not so manageable.

A healthy woman, aged thirty-eight, broke a chamber-vessel by her weight, and was brought to the Middlesex Hospital with a bleeding wound in the nates of the right side, inflicted by one of the fragments.[1] The wound was situated by the side of the coccyx, and passed deeply into the pelvis. Arterial blood issued from it at first in considerable quantity, and then ceased to flow; but it burst forth again from time to time, and the wound was enlarged at both ends with the object of finding the vessel. Nothing could be reached, however, but a large cavity in the pelvis, from which blood welled up. The wound was therefore plugged, and blood ceased to flow. Again, however, the bleeding returned. On the eighteenth day she was greatly exhausted, restless, panting, pale, and pulseless. While in this state she suddenly died.

Post-mortem examination.—The wound opened within the pelvis into a cavity nearly large enough to contain a child's head. Extravasated blood reached upwards behind the peritoneum to the diaphragm on the left side, and to the kidney on the right. The principal branches of the internal iliac artery were unhurt; but the internal pudic, before leaving the pelvis, was exposed in the cavity, and covered by some recently formed lymph. The vein was cut completely across; the artery in the same line of incision was half divided. The wound in the artery gaped widely, and there was no clot in any part of the canal of the vessel.

Wounds of this form in larger arteries, when left to themselves, are more rapidly fatal: death takes place before the formation of any fibrinous plug. The possibility of the existence of such a wound confirms the propriety of the advice that the ligature should, as a rule, be preferred to other measures for arresting arterial hemorrhage.

When an artery is *completely divided*, a great difference in the effects is observed according to the manner in which the injury occurred. There is rarely any great hemorrhage from the brachial or femoral artery when a limb is torn off by machinery; whilst when cut across, an artery bleeds most profusely. In the latter case, the open mouth of the artery pours forth blood until the patient dies, or the opening spontaneously contracts, or is closed by an external plug; in the former, the external coat is dragged out into a long slender point, even an inch or two beyond the spot at which the inner coats are torn. The vessel hangs out of the wound, diminishing almost to a point, and pulsating to its very extremity. Arteries completely divided on the battle-field bleed, or not, as their injury approaches one or other of these forms.

An artery of moderate size, when completely divided, usually ceases to bleed, and no hemorrhage is renewed from either end of it. There are, however, instances of great importance on record, in which such vessels by continuous bleeding have thrown out a very great quantity of blood. Branches of the axillary artery sometimes bleed thus largely into the loose tissues of the axilla; and as the enormous and tense swelling presents no pulsation, it might be supposed that the injured vessel was a vein.[1] Mr. Liston, however, has recorded an example of such a wound of a small branch of the common femoral artery, in which the swelling did pulsate, and on account of which he deemed it necessary to tie the external iliac artery. It is important to bear in mind the possibility of formidable aneurisms thus springing from wounded smaller arteries, whilst, on the contrary, the lacerations and complete divisions of trunk-vessels may not for days be indicated by either hemorrhage, aneurismal swelling, or failure of life in the limb.

It sometimes happens that the first clear proof of the entire division of an arterial trunk is furnished to the surgeon by the occurrence of gangrene in the lower parts of the limb. Arterial pulsation having ceased below the wound, the maintenance of life in the limb is dependent on the establishment of the collateral circulation. This fortunate occurrence somewhat rarely happens under such circumstances, and the probability of it is less in proportion to the severity of the whole injury, and to the swelling of the limb. The gangrene which attacks the extreme parts of a limb, in

[1] The hesitation of the patient, and other circumstances, raised a suspicion that she had been stabbed. But another person is reported to have been found dead from sudden hemorrhage after a similar accident.

[1] J. Bell, Surgery, p. 448.

some instances creeps slowly on, and may stop; but that in which the higher parts die early, extends with great rapidity, and is speedily fatal.

Treatment of wounded Arteries.

The methods of treatment described in the chapter on Hemorrhage are sufficient to arrest most cases of bleeding. When, however, the flow of blood is such as to require artificial obstruction of an artery, by ligature or otherwise, various questions arise, the answers to which may be arranged in the following Rules. Hemorrhage should be prevented during the necessary manipulations by the employment of a tourniquet, or by compressing or even exposing the trunk-vessel above the wound.[1] [The use of Esmarch's elastic band will sometimes facilitate the search for a bleeding vessel, especially if the wound is a recent one, or if any dissection is necessary.]

1. Wounded arteries, which do not readily cease bleeding, and which can be conveniently secured, should be tied. A surgeon need no more hesitate to adopt this rule in a case of accidental wound than he would after an amputation.

2. Moderate hemorrhage from an artery which cannot be reached without enlarging the wound, should be stopped by a graduated compress. Compression upon the arterial trunk above the wound may be added, if it is thought advisable. In the majority of cases such hemorrhage will not return.

3. Violent arterial hemorrhage requires the wound to be enlarged, and the vessel tied. This rule is justified by the necessity of the moment, and by the possibility that a recurrence of such hemorrhage might prove fatal, even if it should cease before the patient were exhausted.

4. No operation should be performed with the object of securing a wounded artery unless it be actually bleeding. On the one hand, an operation has ceased to be necessary; and, on the other, the operator is very likely to fail in finding the wound of the vessel in the absence of the only sure guide to it, namely, the bleeding.

This rule may nevertheless be departed from when the torn extremity of a large artery is seen or felt to pulsate, and its permanent closure by natural means appears doubtful. An artery which has recently ceased to bleed may also be cut down upon and tied in certain emergencies. Such practice may be judged to be right when delirium tremens supervenes upon the injury, or when, as in some military movements, the wounded are ordered to be transported to another position. An instructive instance, in which this precautionary measure probably saved a man's life, is detailed in the Surgical History of the British Army, etc. vol. ii., p. 345.

5. A wounded artery, when requiring a ligature, should be tied in the place where it bleeds. The reasons for this rule are as follows: *a.* When the trunk is tied higher up, the hemorrhage may be renewed by branches which pass off between the ligature and the wound, so soon as the collateral circulation is established. A fibrinous plug may have formed in the hole of the artery, yet if, as the collateral circulation gains volume and force, the plug do not *pari passu* consolidate and cohere, there comes a time when the returning blood thrusts it away, and hemorrhage is renewed. It is impossible in any case to predict with certainty whether the circulation will first be re-established, or the wound will first be healed. A ligature on the subclavian will ordinarily stop the bleeding from a wounded axillary artery. The ligature of the external iliac will ordinarily fail to do so when the femoral is wounded. Now, as the double ligature at the wound secures not only those patients who may recover when the trunk-vessel is tied at a distance above the wound, but also those who would die by that procedure, there seems no doubt that, if he can tie the vessel in the wound, the surgeon should abstain from the higher and easier operation, and, cutting directly upon the vessel, should tie it above and below the wound. *b.* This course is further advisable since it is sometimes impossible, before finding the artery, to be certain that the trunk is wounded. It may be that only a branch of the main artery needs to be tied, but the higher operation necessarily obliterates the arterial trunk. *c.* In certain situations additional danger to life is incurred by the higher operation. Mr. Liston's fatal case[1] is an instance in which, a small branch only of the common femoral artery being wounded, the external iliac was tied, and the patient died the next day of peritonitis. He would indeed, in all probability, have died under any treatment, or with none; but it will be observed that his death arose from a cause entirely unconnected with the original wound. *d.* If after ligation of the trunk at a distance, it should become necessary to tie it again in the wound, the probable issue of the double obstruction to the circulation would be gangrene of the extremity; and amputa-

[1] Med.-Chir. Trans., vol. xliii. Syme, On the Treatment of Aneurism.

[1] Med.-Chir. Trans., vol. xxix., p. 157.

tion, as a third operation, would be most frequently fatal.

Nevertheless, since it is sometimes impracticable to tie the vessel in the wound, the trunk should then be secured at the next convenient place above the bleeding orifice. No other practice can be adopted in hemorrhage into the mouth from the internal carotid artery, or in cases of external wounds which penetrate the floor of the mouth, dividing branches of the external carotid in their course. The ligature of the common carotid in such cases has proved successful. The internal iliac may require to be tied for wounds of its branches within the pelvis, and the radial, ulnar, or brachial, for some wounds of the palmar arch.

6. The external wound should be taken as the guide for the incisions. Muscles, and other intervening structures, the division of which does not endanger life, may be cut into or across in order to reach the bleeding point. When, however, the orifice of the wound is on the opposite side of the limb to the artery which is presumed to be the source of the hemorrhage, a probe may be passed through the wound. The incisions made, where its point is felt, in the known vicinity of the large arteries, will lead to the bleeding vessel.

7. In exposing a wounded artery, the bleeding from which cannot be restrained by pressure on the trunk, the greatest precaution must be taken against the needless escape of blood. Cases are on record in which the hemorrhage has proved instantly fatal. Whatever incisions it may be convenient to make through the skin and muscles, it is not at first advisable to enlarge the deeper part of the wound itself more than is necessary to admit the finger to the artery. The warm gush of blood guides the finger to the orifice in the vessel, and as soon as that is compressed, the soft parts may be divided at leisure to any requisite extent. John Bell's[1] description of the operation by which he secured a wounded gluteal artery, and that in which Mr. Syme[2] tied the common carotid, may be contrasted in this respect. In the former there were long incisions and vast hemorrhage; in the latter, an aperture was made only large enough to admit the finger, which was insinuated into the aneurism with the knife; the hole in the artery being felt for and compressed by the finger before the incision even through the skin was further enlarged, there was no hemorrhage.

[Mr. Syme's operation, one of the most remarkable and creditable in the history of surgery, teaches so valuable a lesson, and may be of so much service in giving the surgeon courage and confidence when called upon to face the most trying of surgical emergencies, that its record deserves reproduction here.

The case was one of aneurism of the lower part of the common carotid, caused by a stab received two months before the operation. The tumor was as large as an orange, extending under the clavicle, and throbbing with great force. Nearly at the centre there was a cicatrix, showing where the wound had been.

"Chloroform having been freely administered, and the patient being placed upon his back, with his shoulders slightly elevated, I pushed a knife through the cicatrix, and followed the blade with the forefinger of my left hand so closely as to prevent any effusion of blood. I then searched through the clots and fluid contents of the sac for the wound of the artery, and found that pressure at one part made the pulsation cease; keeping my finger steadily applied to this point, I laid the cavity freely open, both upward and downward, turned out the clots, and sponged away the fluid blood, so as to get a view of the bottom, which presented the smooth shining aspect of a serous membrane, without the slightest indication of either the artery or vein that could be seen or felt. In order to make the requisite dissection, I next attempted to close the orifice by means of forceps, but found that it had the form of a slit, which could not be thus commanded. It was also so near the clavicle that pressure could not be employed below it, and, to my still greater concern, lay on the inner or tracheal side of the vessel, so that the compression required for its closure, instead of being backward upon the vertebræ, was outward upon the vein. In these circumstances it seemed proper, so far as possible, to lessen the opposing difficulties, and I therefore ran a bistoury through the skin and the sternal portion of the sterno-mastoid, so as to divide this part of the muscle, together with the superjacent integument. I then seized the edge of the slit in the artery, as it lay under my finger, with catch forceps, and desired them to be held so as to draw the vessel toward the trachea, while still subjected to compression; then carefully scratched with the point of a knife until the arterial coat was brought into view at its external edge, a little above the aperture, where a ligature was passed by the needle and tied. I repeated the same procedure below the wound, and, when it was completed, had the satisfaction of finding that my finger could be withdrawn

[1] Principles of Surgery, 1826, vol. i., p. 375.

[2] Edinburgh Medical Journal, vol. iii., p. 105.

without the slightest appearance of bleeding, instead of the tremendous gush which had previously attended its slightest displacement." The ligatures separated on the tenth day, and the patient was discharged in a month.

"I have thus particularly related the steps of this operation, because it was by far the most arduous that has ever occurred in the course of my surgical experience. Indeed, even now I cannot, without a shudder, reflect on my position, when the slightest displacement of one hand must have instantaneously caused a fatal hemorrhage from the carotid artery, and a wrong direction of the needle by the other, to the smallest possible extent, would have given issue to an irrepressible stream from the jugular vein."[1]]

8. The artery, when found, should be tied both above and below the wound in it. The necessity for tying the lower end is the greater, because it is the more frequent source of secondary bleeding. When the lower end of the vessel cannot be found, a piece of compressed sponge left in the wound sometimes prevents subsequent hemorrhage. This plan has been known to succeed when the wounded artery was the popliteal, and to fail when applied to the lower end of the radial artery, between the first and second metacarpal bones. For wounds of arteries near their bifurcation three ligatures are indispensable, as either branch may furnish the recurrent hemorrhage. The observation applies to the common carotid, brachial, and popliteal arteries, to the double bifurcations with which the first inch of the posterior tibial and ulnar arteries is connected, and generally to all cases in which bleeding continues after the application of two ligatures.

9. It is not advisable to apply a single ligature immediately below the origin of a large branch. Secondary hemorrhage does not, indeed, necessarily take place, but its occasional occurrence shows that the repair of the vessel is uncertain. The propriety of avoiding the neighborhood of large collateral branches, when choice is possible, is confirmed by the rarity of secondary hemorrhage after the ligature of the common carotid and external iliac arteries, which do not give off collateral branches.

10. Recurrent hemorrhage, as well as that which happens upon the separation of a ligature from an artery, is to be treated according to its severity and the color of the blood. When the blood is bright in color and flows with alternating impulse, it issues from the upper end of the artery. As a general rule, the bleeding being great, it would be safest to tie the artery in healthy tissues between the orifice and the origin of the next collateral branch above it. If that cannot be effected, amputation, if practicable, should be performed above the bleeding point. If that be not practicable, pressure and astringents must be employed, and aided by indirect compression or ligature of the trunk higher up, according to circumstances. Astringents, however, are of little avail in wounds of large arteries in the human subject.[1] Blood from the lower end of an artery approaches the color of venous blood, and flows without cardiac pulsation. Such bleeding can usually be arrested by astringents and pressure, especially if care be taken to apply them directly upon the orifice of the vessel.

11. There are circumstances in which eminent practical surgeons have deemed it less perilous to remove a limb than to search for a wounded artery in it. The propriety of this measure is sometimes founded on the exhaustion of the patient by previous hemorrhage, sometimes on the state of the limb. Mr. Lawrence amputated a leg one month after a wound of the calf, on account of the continuance of hemorrhage from the posterior tibial artery, "the swollen state of the limb and the reduced condition of the patient" forbidding the attempt to secure the vessel in the wound.[2] In a case of compound fracture, complicated with a wound of the posterior tibial artery, the lower end of the vessel went on bleeding for four months, and the limb was then amputated.[3] Mr. Syme has published a case of hemorrhage from the axillary artery, not cured by the ligature of the subclavian, in which he amputated the arm at the shoulder-joint. The patient recovered; but it is open to question whether he would have done so, if, instead of removing the limb, Mr. Syme had cut off the supply of blood to it by tying the axillary artery, after having already tied the subclavian.

[In Mr. Syme's second case of amputation at the shoulder-joint for axillary aneurism, caused by the patient throwing his arm violently upward and backward, and in a case recently published (The Lancet, Aug. 14, 1880, p. 260), in which the same operation was done by Mr. Bellamy for an axillary aneurism caused by an attempt to reduce an old dislocation, the arteries were found so altered that they could not have been secured by liga-

[1] Syme's Surgical Works, edited by Maclean, p. 829.]

[1] Med.-Chir. Trans., vol. xvii., p. 121. Cæsar Hawkins, on Stypties in Hemorrhage from Arteries.

[2] Med.-Chir. Trans., vol. xxix., p. 52.

[3] Alanson, On Amputations, p. 233.

ture. Mr. Syme says he "found no distinct orifice (of the artery) but merely a funnel-shaped expansion where it communicated with the aneurism." He controlled the bleeding by pressure upon the opening, "made an incision from the upper extremity of the wound quite to the clavicle in the direction of the vessel, cut through the tendon of the pectoralis minor, and by careful dissection of the condensed tissues in which it lay imbedded, exposed a sufficient portion of the artery for safely applying the ligature." The patient recovered.

In the other case it is said, "there was a hard cartilaginous-like tube on the wall of the thorax, throwing a fearful jet of blood," which was secured with great difficulty. The patient died in an hour. The difference in the methods adopted to secure the vessel, explaining perhaps the difference in the results, deserves attention. In both cases the operation was rendered necessary by impending rupture of the sac.]

Again, to be in an urgent case deprived of competent assistance must sometimes determine a prudent surgeon to amputate rather than to attempt to secure the vessel. See the account of the difficulties attending the operation of tying the posterior tibial artery in Mr. Arnott's case.[1]

12. When it is ascertained that the principal artery of a limb is obstructed, whether by contraction, partial laceration, or complete division, as well as when a ligature has been applied upon it, no tight plaster or bandage should encircle the limb; no cold should be applied to it; but all care must be taken to preserve its life. A flannel bandage may be rolled around it; or, until an increase of its temperature shows that the collateral circulation is being established, it may be long and lightly chafed by the hands of nurses.

13. If, nevertheless, gangrene should come on, the treatment will depend upon the rate of its progress and the state of the patient's system. No delay in amputating should be permitted when the mortification spreads rapidly, with swelling of the limb and increasing depression of strength. It may be permitted to wait for the formation of the line of demarcation, when the gangrene commences at the digits, and ascends slowly for days or for weeks.

A limb affected with a rapidly-spreading gangrene should be amputated above the affected parts, and, as a rule, at the level of the obliteration of the artery. When, however, the femoral artery and vein have been divided by a mere cut as high as Poupart's ligament, and mortification of the foot supervenes, the limb may be removed at or a little below the knee.

14. A wounded aneurism, when itself the result of an injury of an artery, is to be treated as a wounded artery. The wound of a spontaneous aneurism, in which the artery must be presumed to be diseased, is best treated by the amputation of the limb.

The subjects of traumatic aneurisms, arterio-venous tumors, and the operations for securing the several arteries, are treated in the essay on ANEURISM.

WOUNDS OF VEINS.

No instance of healing can be more perfect than that of an incised wound of a vein. If made longitudinally in the course of the vessel, and carefully closed and compressed, as is done in ordinary venesection, no trace of the incision of the vein is discoverable a few days after the operation, even on the smooth interior membrane. Even irregular lacerations heal with readiness, and with little scar. No impetuous outburst of blood separates the edges of the wound, as in arteries; for the weaker venous current is very readily controllable by well-adjusted pressure, even in very large veins. It consequently happens much more frequently in veins than in arteries, that a wound is repaired without the obliteration of the canal of the vessel. Surgeons have taken advantage of this circumstance in lateral wounds of large veins, as the femoral and internal jugular; instead of encircling the whole vessel in a ligature, they have raised and tied only the edges of the wound itself. The canal of the vein has thus been left open, and only narrowed according to the extent of the calibre of the vessel which has been included in the ligature. Such wounds usually heal, but sometimes a vein thus treated becomes lined with lymph, and the patient dies pyæmic. It is therefore preferable to plug the wound, and even for a few hours to reduce the circulation by acupressure of the vein or of the adjoining artery in the wound.

Veins possess a power of contraction, and when divided in amputation, they may be seen after a time to have diminished a little in calibre. But this power is very feeble and slow in exercise, and renders these vessels quite incapable of arresting hemorrhage, either in the onward or retrograde direction of the venous current. Pressure, however, will readily control the bleeding of even large veins, and the freedom of their collateral communications lessens the force of the stream which issues from them. Pressure is also usually sufficient to arrest the

[1] Med.-Chir. Trans., vol. xxix., p. 46.

bleeding from the largest veins divided in amputations; though occasionally, when the loss of blood may seriously affect the issue of the case, it is wisest to tie them.

Lacerations of veins by external violence are of separate importance only when the larger vessels are injured, as in a case described in a previous section, at page 462. The inferior cava was lacerated to the extent of an inch, and the patient lived three hours. The duration of life after injuries of veins may sometimes, therefore, be considerable. In another instance a man lived several hours with a wound of the lung, a rupture of the subclavian vein, and a fractured clavicle.

Some examples of spontaneous rupture of veins are on record. When greatly distended, they burst. Veins of the internal organs have sometimes been thus ruptured during the cold stage of an ague.

On the Entrance of Air into wounded Veins.

A most startling occurrence has occasionally happened during certain surgical operations. Whilst everything has been proceeding with perfect regularity and success, the sudden onset of most alarming symptoms, or instantaneous death, has unexpectedly arrested the operation. The accident is happily a rare one, but it has been observed sufficiently often to allow of our arriving at some conclusions with regard to it. In all the cases the operation which has been interrupted by this disastrous occurrence has been on the neck or the axilla; in all a sound of hissing, whistling, or gurgling, has been heard by the bystanders, and this has been followed in not a few instances by death. In the words of Sir Charles Bell,[1] "Neither violence, nor loss of blood, nor even the bursting of the aorta, nor nervous influence, produce effects so sudden and appalling as this cessation of motion as by a lightning-stroke." In those cases in which the peculiar noise was not followed by instant death, symptoms of a dangerous character immediately supervened, for which nothing in the previous state of the patient could have prepared an observer. Both results probably spring from the one accident of air entering the heart, the difference in the two cases arising from the quantity of air admitted, a large quantity extinguishing life at once, a smaller quantity causing the violent but not fatal symptoms. A sound is sometimes heard in an operation corresponding to that described as accompanying the entrance of air into a vein; but it is not followed by any symptoms. It may occur on opening the fascia of the axilla, or any space similarly protected from atmospheric pressure.

It will be well first to quote some of the cases in which the fact of death or violent symptoms following the entrance of air into the veins has been ascertained; next, to determine how the air enters; then to inquire how its presence in the system exerts the prejudicial effect attributable to it; lastly, the means of preventing and, if possible, relieving the symptoms.

1. It has long been known to veterinary practitioners that the presence of a considerable mass of air in the veins of animals proves fatal, and the practice of killing horses by means of the injection of air is still sometimes adopted. The fatal quantity is well known, being about thrice that which can be blown at one expiration from the lungs of a healthy man.

On November 22, 1822, Dupuytren excised, without difficulty or hemorrhage, a tumor from the posterior and lateral part of the neck of a healthy young woman. As an assistant was raising the tumor, and the operator was separating its last attachments, a prolonged noise (*soufflement prolongé*) was heard in the wound, like that of air rushing into an exhausted receiver. "If it were not that I am far from the air-tubes," said Dupuytren, "I should have supposed we had opened them." The words were hardly spoken when the girl exclaimed, "*Je suis morte;*" she trembled, and fell dead.

"The right auricle was distended like a bladder with air, which rushed out, unmixed with blood, when the auricle was opened. Blood and great quantities of air were found in all the vessels, and fluid blood in the other cavities of the heart. There was no unnatural appearance in any other part of the body."

In the sixteenth volume of the Medico-Chirurgical Transactions, Mr. Barlow, of Blackburn, recorded an instance of yet more sudden death. "On proceeding to dissect the skin aside to get at the basis of the tumor (one of large size in the side of the neck), a sudden and unexpected hissing, gurgling noise rushed obviously from a large divided empty vein, and the patient expired instantly without either sigh, groan, or struggle. Scarcely an ounce of blood had been lost." The author adds: "The vein appeared flabby and empty. The instant the atmospheric air gained access and filled the vacuum, the hissing noise ceased, the patient expired, and the mouth of the vessel collapsed." (P. 29.)

In the 27th volume Mr. Bransby B. Cooper described a case which did not prove fatal. After removing the limb at the shoulder joint, and securing the vessels, "I proceeded," he writes, "to remove a gland from the axilla, and while dissecting it from its cellular attachments, I distinctly heard a peculiar

[1] Practical Essays, 1841, p. 11

gurgling noise, like air escaping with fluid from a narrow-necked bottle, and at the same instant the patient fell into a state of collapse, threatening immediate dissolution; the countenance was deadly pale, the pupils fixed, and inobedient to light; the pulse quite small and fluttering, although at intervals regular; the respiration hurried and feeble, and, at irregular intervals, attended with a deep sigh." She uttered a continual whining cry, and maintained a constant motion of alternate flexion and extension of the right leg, while the left remained perfectly quiescent. Symptoms of great prostration continued for several days, but she eventually recovered from the operation. She still dragged the left leg in walking when discharged from the hospital, six weeks after the operation.

Dr. Mott, again, Professor of Surgery in the University of New York, having divided the facial vein where it passes over the base of the lower jaw, in an early stage of an operation for the removal of a tumor, heard the gurgling noise of air passing into some small opening. "The breathing of the patient immediately became difficult and laborious, the heart beat violently and irregularly, his features were distorted, and convulsions of the whole body soon followed to so great an extent as to make it impossible to keep him on the table. He lay on the floor in this condition for near half an hour, as all supposed *in articulo mortis*. As the convulsions left him, his mouth was permanently distorted, and complete hemiplegia was found to have ensued; an hour or more elapsed before he could articulate, and it was nearly a whole day before he recovered the use of his arm and leg."

With these cases the following one may be classed, as the death in it appears to have originated from a similar cause, although not in similar circumstances. A private soldier, æt. 20, was wounded near the left knee-joint on the 18th June, 1855. On the 21st September amputation was performed immediately above the knee, and the dressings were removed on the 23d. At one spot, towards the inner portion of the stump, and near to one of the sutures, a small portion of the integument looked likely to slough. On the following day, the 24th, the stump looked better, but healthy suppuration had not been set up, and the discharge was thin, watery, copious, and slightly fetid. He was quite comfortable and in good spirits. The stump was dressed with water-dressing and oiled silk. "To our great surprise he died *suddenly* in the night." He had been talking and comfortable at eleven at night, and at one in the morning he was found by the orderly quite dead and nearly cold. A wounded sergeant in the next bed was unconscious of his death, so quietly had it taken place.

"On examination, twelve hours after death, the lungs were found healthy, but somewhat anæmic. The right auricle was full to distension of bright red froth (air mixed with blood), as was also the right ventricle, but the comparative quantity of air was less in the latter than in the former; the heart was otherwise quite healthy. The ascending cava was full of the same kind of frothy blood, of a bright scarlet color, and distended by it, so that it felt like a portion of small intestine before it was cut into. This appearance extended as low as the junction of the two common iliac veins, but not lower. The surface of the stump had a grayish, sloughy, unhealthy look; there was no attempt at union except at one or two points of the integuments, and the surfaces were separated to some extent by gaseous products, having a fetid odor, the smell of which was, however, that of decomposition rather than the peculiar odor of gangrene, and they were smeared with a dirty-looking sanio-pus. The periosteum was stripped from the femur as high as the intertrochanteric line, except at the linea aspera, and both bone and membrane smeared with the same secretion. There was no attempt at closure of the femoral vein, which lay quite open on the face of the stump, but its extremity was not sloughing."[1]

2. Upon the expansion of the chest in inspiration, an instant rush of atmospheric air takes place in all directions towards the thoracic cavity. The walls and floor of the chest support the weight of the atmosphere, and are not pressed in, but all the parts above the clavicles and sternum yield to it more or less. So far as the muscles and their fasciæ allow, the soft parts at the root of the neck are forced in towards the chest; but the vacant space in the thorax is chiefly filled by air, venous blood, and the contents of the cervical portion of the thoracic duct. Air promptly enters by the open trachea, and distends the lungs. If the pleura were opened, it would rush in there, and has been known to do so with a whistling noise in the operation of ligature of the subclavian artery. The veins of the neck, which during expiration have gradually enlarged from below upwards, become empty and invisible with amazing celerity at the instant when the lifting of the chest leaves them unsupported under the weight of the atmosphere. Though not visible, the cervical curvature of the thoracic duct is probably subject to the same weight. Filled by the act of expiration, which forces on the lymph from the abdomen and chest, it is emptied during inspiration by direct compression under the weight of the atmosphere, its valves securing that the current of lymph should not be retrograde. The same weight may act upon parts more distant from the thorax than the neck. My colleague, Mr. De Morgan, informs me that he has seen a greatly dilated saphena vein in the

[1] Medical and Surgical History of the British Army in Turkey and the Crimea, vol. ii., p. 277.

groin emptied by a few vigorous inspirations. This could happen from no other force than the pressure of the atmosphere upon it. If now a vein in the neck or axilla, or a large cervical absorbent vessel, be held open during inspiration, the air must rush along it into the chest in precisely the same manner and for the same reason that at the same moment it is rushing down the trachea. It, however, passes into the right side of the heart instead of into the lungs.

3. The mode in which death results from the presence of air in the heart is still a subject of speculation. It is clear that a small quantity is not enough to prove fatal. Sir Charles Bell was of opinion that the instantaneous death arose from the access of air to the medulla oblongata. There is, however, no evidence that the air in the suddenly fatal cases has passed beyond the right side of the heart. The evidence is that the air in the heart destroys the life.

In the examination of the bodies of persons who have died after the accidental entrance of air into the heart, the largest quantity of air is always found in the right side of the heart. The most sudden deaths occur when the most air and the least blood are discovered in the right auricle and ventricle, and when the two fluids are least intermixed. In the same instances the lungs are found pale, and the left side of the heart contains but little blood, while the systemic veins are full. The appearances somewhat differ from this when life has been prolonged after the moment of the accident; the blood and air are then found frothy, and this froth is found, not only in the right heart and systemic veins, but also in the pulmonary arteries and their branches; there may even be air in the left side of the heart and the systemic arteries. The proportion of blood found in the systemic veins being still in excess over that in the lungs and arteries, the fact of the circulation being arrested in the right chambers of the heart is again established.

How does this arrest take place? Upon a right perception of this depends that of the whole mechanism of the accident, as well as that of nearly all the treatment it admits of. When air enters the right ventricle, and the ventricle contracts, a part only of its contents passes into the pulmonary artery; the remainder regurgitates into the auricle. For the wet tricuspid valve is not raised from the wall of the ventricle by so thin a fluid as air, and consequently does not close the auriculo-ventricular opening. In subsequent dilatations of the ventricle, additional air enters it from the auricle, and either is forced by the systole, or floats into the pulmonary artery. That which first occurred with the tricuspid valves now happens to the pulmonary—they stick to the wall of the artery and are useless. The ventricle, thus deprived of all assistance from the valves, communicates, both in its systole and diastole, with both its orifices, and draws in from, and restores to, both artery and auricle the contents of both. The blood and air advancing and regurgitating thus at both the orifices of the ventricle, the circulation is nearly at a stand. Mr. Erichsen, in his essay on this subject,[1] after accurately describing much of this state of things, goes on to attribute the stoppage of the circulation to the obstruction which a frothy fluid encounters in traversing the capillaries of the lungs, and to ascribe to the lessened power of the ventricle only a subordinate place in producing the fatal result. That such a fluid encounters an obstruction he proves; but not that the obstruction causes death: and he leaves unexplained those cases in which death takes place before the blood and air are mingled into the "spumous froth," and in which, therefore, the obstruction in the lungs never occurs. The experiments and researches of Dr. Cormack on this subject led him to ascribe the obstruction of the circulation and the death to the great distension of the right side of the heart with air, not to inaction of the valves.

4. In the way of prevention of this distressing accident, the surgeon must be observant of the danger and close instantly the mouth of any vessel which may be opened in localities known to be liable to it. He may appoint an assistant to compress the vessels between the site of his operation and the thorax, or to compress and close the veins both on the proximal and distal side of the wound. They will thus be kept both empty and motionless. He should avoid forcibly lifting a tumor from its bed, or suddenly raising the shoulder, a movement which might open the wound of a vein in certain situations, and permit the ingress of air into it.

Should air have entered a vein in sufficient quantity to embarrass the heart, the treatment must depend upon the symptoms. In those cases which do not speedily present the appearance of imminent death, it may be assumed that only a small quantity of air has reached the heart; that organ must therefore be aided in *gradually* forcing the air along the pulmonary artery. Such a case should be treated (1) by placing the patient in the supine posture, with the head low and

[1] Edinburgh Medical and Surgical Journal, No. 158, p. 14.

the feet high ; (2) by chafing the limbs in a direction towards the heart ; and (3) by the administration of stimulants.

1. The advantage of the recumbent posture may be looked for in the brain, which approaches, or is actually in, a state of syncope ; from the posture being supine it will result that a part of the air in the auricle will be detained in the auricular appendix, and that all the blood which reaches the ventricle will be in position at the back of the heart to raise the tricuspid valve. The same difference in the specific gravities of air and blood must, indeed, equally raise air to the pulmonary valves as into the auricular appendix, and the inaction of those valves must probably be as fatal as that of the tricuspid. But our endeavor must necessarily be to restore that valve to action on which contraction of the ventricle depends. The tricuspid valve once efficient, the circulation is restored ; the remaining air will be carried along with it.

2. The recommendation of Mercier, to compress the femoral and axillary arteries, would be suitable, if the compression did not at the same time obstruct the corresponding veins. It would undoubtedly be to the advantage of the brain to receive all the blood which without that compression would descend to the limbs. But the great point in our treatment is that of propelling into the right side of the heart blood which is kept by the air from entering it by the ordinary powers of the circulation. The right heart contains air, and is acting uselessly for want of blood: the systemic veins are full of blood. What is needed, then, is that the veins should be emptied towards the heart by elevating the limbs and chafing them.

3. The administration of stimulants is called for both by the heart and the brain. Strong ammonia should be held near the nostrils, and brandy should be introduced either into the stomach or rectum. If the heart should lose instead of gaining power, shocks from the galvanic battery should be passed across the chest.

When the quantity of air in the heart is so great as to occasion sudden syncope, the circulation is almost or completely stopped, and the patients are described as dead. As, however, in apparent death from drowning, resuscitation may be possible although all signs of animation have disappeared, it will be right to attempt to restore the patient even in such desperate circumstances. The difficulty being as before, the inaction of the valves, the principle of the treatment is the same, but the mode of carrying it out is different. Chafing or elevation of the limbs will not force the venous blood into the right side of the heart, which is already full of air. With the need of a denser fluid than air, there is also distension of the right chamber to be met, which prevents the contraction of the ventricle. It is necessary to relieve the heart of the air which burdens it, as well as to restore to it a fluid in which its valves can act. It might be possible, by closing the mouth and nostrils while making a few thoracic movements of artificial respiration, to expel the air from the heart through the vein by which it entered. And it has been suggested to suck out the air by a pipe passed into the heart through a vein in the neck. The only remaining plan appears to be the injection of warm water into the heart. By means of this, the air would in part be replaced by a fluid in which the valves would be again mobile. The nozzle of a syringe being inserted into a vein, water could be injected towards the heart. It would be further advisable, 1. To raise the neck above the level of the heart ; that, as the water is forced down, the air in the heart may rise. 2. To open a vein in the neck, and evacuate the blood in it ; that, if air ascend during the injection, it may find space or escape. 3. To throw in no additional air by a careless filling of the syringe. 4. To inject with force enough to insure that the water reaches the heart, which the venous blood, being without a *vis a tergo*, cannot do, and yet with force so moderated as not to distend the right cavities. 5. To inject at a time about two ounces of fluid, and with sufficient velocity to insure its not slowly trickling into the heart, which would be useless, but accumulating therein a quantity suited to raise the valves. 6. During the whole process the action of the heart may be solicited and maintained by galvanic shocks, all means being, of course, in vain without the action of the heart.

FRACTURES.

By Thomas King Hornidge, Esq.

Revised by John H. Packard, M.D.

Fracture may be defined to be a sudden, violent solution of continuity of a bone.

Causes.—The causes of fractures are of two kinds: predisposing and determining. The predisposing causes are certain natural agencies, viz., the age and sex of the patient, and the liabilities of different bones. Some morbid conditions of the bones, which render them unusually fragile, are also commonly included under this title, though in such cases it is more correct to regard the fracture as an accidental accompaniment of the primary disease.

The influence of age goes nearly hand-in-hand with the liability to exposure to the external causes. The smallest number of fractures is found in infancy, especially between the ages of four and five. At puberty, and again at the age of twenty-five, there is a sudden rise in their ratio; thence the increase is small, but gradual, up to the age of sixty, beyond which the proportion is stationary. The increase after forty must be ascribed to the changes in the bony tissue which occur at that period of life. Certain fractures may be considered the peculiar appanage of old age; as fracture of the neck of the femur, or of the lower end of the radius [but in a limited sense only].

As might be expected, men are much more liable to fractures than women, except in early infancy and in extreme old age. The differences in the development and decay of the skeleton sufficiently explain these exceptions. [Moreover, the occupations and habits of life of the two sexes are much more alike in childhood and in old age than in the intermediate periods.] There are also wide differences in the liabilities of different bones, depending on their form, position, functions, and structure; the long bones suffering most, especially those which are most exposed to the violence of falls.

The morbid conditions of bone which predispose to fracture are either confined to the bone itself, or are parts of a general cachexia. Of the former kind are atrophy, caries, necrosis, chronic inflammation, tumors of all kinds in the bone, and ulceration in consequence either of the pressure of an aneurism or tumor external to it, or of the spreading of an ulcer from the soft tissues.[1] In all these cases the fracture is to be regarded rather as a complication of the more formidable disease. The general predisposing affections mentioned by authors are scurvy, cancer, gout, syphilis, scrofula, rickets, fragilitas and mollities ossium.

Scurvy does not appear in general to have any injurious effects on sound bone, though in one case Bérard found the bones of the lower extremity congested and fragile.[2] Numerous instances have been met with of unusual fragility in cancerous subjects; but in all (with, perhaps, one only exception, mentioned by Rumpelt[3]) nodules of cancerous deposit have been found embedded either on the surface or in the interior of the bone.

Gout and rheumatism have been imagined, rather than proved, to weaken the tissue of bones. Not so, however, with secondary syphilis. M. Donatus mentions the case of a syphilitic patient in whom very slight exertion produced a fracture, at one time of the right humerus, at another of the left.[4] Since that, many cases of the kind have been recorded. In two of B. Bell's patients the thigh-bones were broken by a slight force; and Brodie has seen the clavicle give way at the seat of a node.

[In the Med. Times and Gazette for Feb. 14, 1880, there is a report of some remarks made by Dr. Thomas Buzzard at the Pathological Society of London on articular and osseous lesions in locomotor ataxy, with the resulting discussion. A case of Charcot's is mentioned, in which a woman affected with tabes dorsalis had "great disorganization of certain joints, multiple fractures of the neck of the left femur and of both bones of both forearms."

Under such circumstances it would seem also that voluminous callus is apt to be formed.]

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[1] Trans. of Path. Soc., vol. x., p. 234.

[2] Dict. de Méd. en 30 tomes, 1836, art. "Fracture."

[3] Gaz. médicale, 1835, p. 641.

[4] De Hist. Med., lib. v., cap. 1.

But the disease which, more than any other, predisposes to fracture is unquestionably rickets, or its later type, fragilitas ossium. M. Guersant states, that out of a mean of eighty annual cases of fracture in early life, he has found about one-third in rickety children.[1] These cases are of two classes. In some, as in most of those described by Dupuytren,[2] fracture is preceded for some days, or even weeks, by bending, and union is tardy. In others fracture occurs suddenly and repeatedly from the slightest causes. Gibson had under his observation a youth who, at the age of nineteen, had suffered twenty-four fractures, eight of which were in the clavicle.[3] Arnott gives the history of a girl who, between the ages of three and fourteen, had thirty-one fractures, all of the long bones.[4] Analogous cases are recorded by Tyrrell[5] and Lonsdale;[6] and Esquirol possessed the skeleton of a woman, in which the traces of more than two hundred fractures, occurring at different periods, could be counted. In all the above cases the general health has appeared good, and union has not been retarded, nay, more, it has been sometimes unusually rapid. Stanley, however, records a case in which no union could be obtained.[7]

[In the British Med. Journal for June 26, 1880, Mr. R. W. Greenish reports the case of a boy æt. 18, who had himself had thirteen fractures; his grandfather had had "numerous" fractures; his father, one; his uncle, two; his five cousins (children of this uncle), eight, four, four, four, and three respectively; his own brother, two. One uncle and his two daughters had escaped. References are given to observations on this subject by Earle,[8] Fleming,[9] and Jones.[10] A number of additional instances will be found in the classical works of Malgaigne, and still others in Otto's Compendium of Pathological Anatomy, South's translation, London, 1831.]

The immediate causes of fracture are of two kinds: external force, and muscular contraction. The former of these is also exerted in two ways: directly, when the fracture occurs at the part immediately subjected to violence; and indirectly (*contrecoup*), when the force applied at one point is transmitted, and causes a fracture elsewhere. [In the former case the violence acts by crushing; in the latter the bone gives way as an overtaxed lever, there being sometimes also an element of twisting in the mode of application of the force.] Indirect force is probably the most frequent cause, pure muscular contraction the rarest. But in by far the majority of cases the latter co-operates with the more palpable cause, by directly increasing the strain upon the bones, and still more, by fixing them. Hence the comparative facility with which partial fracture may be produced on the dead body, by direct force, and the great difficulty, or, perhaps, impossibility of effecting, experimentally, any kind of indirect fracture. Hence, too, the comparative rarity of fractures among skaters, and the proverbial impunity of drunkards. [This must be an inadvertence. Every hospital surgeon knows that fractures are of very common occurrence to drunken people, who are, however, comparatively exempt from luxations, by reason of the want of the muscular resistance which is a frequent element in the production of these latter injuries.]

The two most prolific causes of fracture are falls and blows. Although, as a rule, falls produce indirect fractures and blows direct, yet they are by no means uniform in their results. A fall may be, and may resemble in its effects a series of blows, as in the case of a fall from a scaffolding. Nothing, in fact, is more apparently capricious than the effects of falls. Thus, a fall on the sole of the foot may fracture either the os calcis, the tibia in any part of its length, the patella, the femur, the pelvis, or even the cranium. The causes of such differences, as well as of the varieties in the form of fracture, are more or less traceable to the degree of violence of the fall, the position of the individual and of the limb, perhaps to the different strength of the bones in different persons, but especially to the precise muscular action called into play.

Neither is there greater uniformity in the mode of operation of these causes. Commonly it is either compression or forced flexion. [*Leverage* would be a more correct word than flexion, especially in reference to the very frequent fractures near the ends of the bones, *e. g.*, the radius.] But in the production of certain fractures torsion has a large share; as in fracture of the fibula and of the ribs, and in fractures of diseased bones during such slight efforts as turning in bed. Traction assists the other causes even in such cases as fracture of the patella, and separation of epiphyses.

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[1] Clin. des Hôpitaux des Enfans, sixième année, p. 28.

[2] Extrait d'un Mém. sur quelques cas particuliers de Fractures, etc., in Bull. de la Faculté de Méd., 1811, p. 156.

[3] Institutes of Surgery, vol. i., p. 370.

[4] Medical Gazette, June, 1833.

[5] St. Thomas's Hosp. Reports, No. 1.

[6] Practical Treatise on Fractures, 1838.

[7] On Dis. of the Bones, 1849, p. 241.

[8] St. Bartholomew's Hosp. Reports.

[9] Edinburgh Med. Journal, vol. iii.

[10] Brit. Med. Journ., Jan. 1870.

The few recorded instances of fracture of the long bones by unaided muscular action can be ascribed solely to violent and sudden flexion. In different cases, the humerus, the bones of the forearm, the femur, clavicle, even the tibia, have yielded during a powerful muscular effort.[1] It is a generally received opinion, however, that no long bone can be broken in its shaft by the mere contraction of its muscles unless impaired by some morbid change in its structure: an opinion confirmed by the observation of Nicod,[2] that in most of these cases fracture has been preceded by pains in the broken limbs, and in some instances followed by actual evidences of disease, as abscess or exfoliation. But abnormal increase of the muscular power, as during convulsions, may be sufficient to account for it. The bones commonly fractured by muscular action are the patella, os calcis, and olecranon. The ribs, and even the sternum,[3] have been known to be broken by the violent action of the diaphragm during coughing, but in all probability they were weakened by partial absorption or atrophy.

The cause of a fracture has considerable influence over its subsequent course and results. It is manifest that, as a rule, the consequences of direct are likely to be far more serious than those of indirect force. For not only are the effects on the bone itself more severe, but the soft parts covering the fracture are subjected to the crushing power of the external violence, in addition to those accidents to which they are equally exposed in both classes of fractures from the displaced fragments.

Intra-uterine fractures originate in two ways. In the majority of cases they are associated with manifest deformity of some part of the body. As many as forty-three, and even one hundred and twelve fractures[4] have been found in the same fœtus, depending, of course, on imperfect development of the bones, or "congenital rickets." But fracture proper, due either to external violence or to abnormal muscular contraction, may occur in the bones of a healthy fœtus. These fractures have been found in all conditions. They are not unfrequently compound, and have been known to wound the uterus, causing hemorrhage and abortion.[5]

[1] For a summary of such cases see Cooper's Surg. Dict., art. "Fracture;" and Hamilton on Fractures and Dislocations, 1860 [1878].

[2] Annuaire méd.-chir. des Hôp. de Paris, 1819, p. 494.

[3] Gaz. des Hôpitaux, mars, 1830.

[4] Chaussier, in Bull. de la Fac. de Méd., 1813, p. 301.

[5] For a full discussion of this matter, see Holmes's Diseases of Children; also a Memoir read before Med.-Chir. Soc., Lancet, April 7, 1860, p. 348.

Varieties.—Fractures are divided primarily into simple and compound; the essential character of the latter being the coexistence of a wound in the skin, with which the fracture communicates. This distinction is important; the two great classes of fractures differing from one another in the nature of the process necessary for their repair, and, consequently, in their results and dangers, and the duration of their treatment. There are two ways in which the wound may be produced at the time of the accident: from without, by the same direct force which fractures the bone; or from within, by the end of one or both fragments being thrust through the soft parts, whether by the continuance of the original force, or by the weight of the body. The latter mode is the more frequent of the two; and it is mainly owing to this that compound fractures are more common in the leg than in any other part of the body. The difference between the two modes of production is essential, and must in all cases be noted. For while the former implies greater or less contusion, almost necessarily followed by inflammation, often by excessive suppuration and sloughing; the latter may be attended by so little injury, as to admit of primary union of the wound, and conversion of the fracture from compound to simple. There are also two ways in which a fracture may become compound at any subsequent period: ulceration of the skin from pressure of a displaced fragment, which most commonly occurs in very oblique fractures of the tibia; and the formation and bursting of an abscess. This accident, the conversion, viz., of a simple into a compound fracture, is most to be feared about the second or third day; but, of course, it may occur later.

Besides this primary division, fractures may be conveniently classed under four heads: I. Simple, single fractures. II. Multiple fractures. III. Incomplete fractures. And IV. Fractures with complications.

I. Of simple single fractures there are two kinds—fracture proper, and separation of epiphyses. Of fracture proper there are also three varieties, named from its direction: transverse, oblique, and irregular or dentated.

Transverse fracture is not met with in the shafts of long bones, though enumerated by most writers. Cruveilhier[1] considers it impossible. Camper[2] was not able

[1] Traité d'Anat. Path. gén., 1849, t. i., p. 86.

[2] Obs. circa Callum, in Essays and Obs. Phys. and Lit. of Soc. of Ed., 1771, vol. iii., p. 537.

to meet with a single specimen of the kind in the museums of Germany, England, or Holland. Neither do those of Paris contain one according to Malgaigne, who also failed in his attempts to produce this kind of fracture in the dead body. Hence it may fairly be concluded that it has never yet been observed. Nevertheless, a fracture may be partly transverse and partly oblique. Transverse fractures occur in irregular and short bones, such as the scapula, lower jaw, patella, and vertebræ; and in the spongy extremities of long bones, as the olecranon and the lower end of the radius; but even in these there is commonly more or less of obliquity.

The great bulk of fractures of the extremities are oblique. The direction of the obliquity may be antero-posterior or transverse, and its degrees are endless; very oblique fractures being often improperly called longitudinal. In dentated fractures the surfaces are studded with irregularities, more or less pointed, and interlocking so as to present obstacles to the displacement of the fragments, or to their reduction when displaced. In such cases the fragments may remain in position, the only perceptible displacement being an alteration in their relative axis, or a bending of the bone. One or more of these points may be broken off, a circumstance which materially affects the nature of the fracture, and the mobility of the fragments. A large proportion of oblique fractures are dentate.

Separation of epiphyses has been so often confounded with simple fracture, or congenital defects, that it is scarcely a matter of surprise that there should still be wide differences of opinion as to its frequency and precise nature. It has been found after death at both ends of the humerus, femur, tibia, and fibula, the lower end of the radius, and upper end of the ulna. It has been diagnosed in other parts, and there seems no reason to doubt that any epiphysis may separate from its bone, the relative facility of the accident at different parts being affected by the mode of growth and connection of the epiphyses.

This is necessarily an accident of early life, usually before the age of sixteen. In some persons, however, in whom complete ossification is deferred, it may occur at a later period. Some surgeons, notably Mr. Smith of Dublin, believe that commonly the fracture follows the course of the cartilage. The majority of French surgeons, however, who have paid much attention to the subject, think that the separation is generally accompanied by some splintering of the adjoining part of the shaft of the bone, and in this opinion they are strongly supported by the investigations of Mr. Holmes.[1] As this latter writer observes, the point is of practical importance only as bearing on the prognosis, the liability to subsequent defective growth of the limb being in proportion to the amount of injury to the epiphysial cartilage. The causes and symptoms of the accident are similar to those of ordinary fracture. It may happen during intra-uterine life from blows received by the mother, and has been not unfrequently produced during birth by violent attempts at delivery.

II. Of multiple fractures there are four varieties: 1. Two or more fractures of the same bone. 2. Separate fractures of different bones. 3. Splintered; and 4. Comminuted fractures.

1. Double fractures in the shafts of the bones are rare, because they can only be produced, either by the simultaneous action of two separate forces, or (which is virtually the same thing) by the action of a single force over a large surface. For the same reason, they are generally attended with great damage to the soft parts, and proportionate danger. But in the articular extremities of certain bones, as the humerus and femur, they are not unfrequent, owing to the peculiar shape of their condyles, between which any transmitted force is divided. Such fractures of course extend into the neighboring joint.

2. Fractures of two or more bones are naturally separable into two groups. One of these includes the numerous cases of fracture of contiguous or parallel bones, as the ribs, the two bones of the leg or forearm, the metacarpal or metatarsal bones. The other group comprises fractures of two or more bones in separate parts of the skeleton. These are comparatively rare, being not more than 1.3 per cent. of all fractures. The leg, the thigh, the arm, and the cranium are the parts most frequently involved. In about one-fifth of the cases there are three separate fractures. More than three are rarely found. The cause of these fractures is almost invariably a fall from a height. As might be expected, they are more fatal than any other class. Produced by great and extensive violence, they are attended with excessive shock, and for the most part with internal injuries. When not so complicated, their danger is in proportion to the number of fractures.

3 and 4. Splintered and comminuted fractures differ from one another principally in degree. A splinter is any pointed fragment, not involving the whole thickness of the bone, except in the case of a

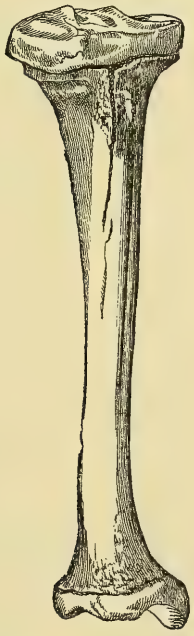
[1] Holmes's Diseases of Children, 2d edit., p. 236.

flat bone. In comminuted fractures the bone or bones are either separated into innumerable fragments which are isolated and scattered among the surrounding tissues; or they are crushed, and as it were compressed, the bony tissue appearing to occupy less space than originally, as though there were actual loss of substance. This latter form of fracture is seen only in spongy bones, as the vertebræ, os calcis, and articular ends of long bones. A variety of it—impacted fracture—of common occurrence in certain localities, as the neck and lower end of the femur and lower end of the radius, differs from it by its capability of repair without loss of tissue or deformity.

III. There are four species of incomplete fracture: 1. Fissures. 2. Proper incomplete fracture, or bending of bones. 3. Separation of a splinter. 4. Perforations.

1. Fissures are most commonly met with in the cranium. In other flat bones, except the ribs, they are rare. There are records, however, of their occurrence in the lower jaw, and in the os innominatum. In the short bones they are still more rare. They occur, though not often, in the shafts of long bones, commencing at the articular extremity, as between the condyles of the femur or humerus, and being prolonged more or less into the shaft. In the preparation (St. George's Hospital Museum, I. 208) from which the Figs. 81 and 82 are taken, a fissure in the tibia of a child, instead of extending to the joint, begins just below the epiphysis, which is partially separated. The fissure, as may be seen, passes obliquely down the shaft of the bone, extending to its inner surface behind (Fig. 82), though in front it is nearly vertical. As is usual in such fractures, there is a distinct separation of the lips. Some surgeons have described longitudinal fissures in the tibia and femur which do not at any point reach the margin of the bone. Malgaigne actually depicts such a fissure, professedly from a specimen in the Museum of the Val de Grâce.[1] But it is difficult to believe in the reality of such fractures, except in the case of radiations from the wounds inflicted by firearms (starred fractures).

Fig. 81.



Fissured fracture of the tibia, front view. St. George's Hospital Museum.

Fig. 82.

Back view of the same preparation.

2. Incomplete fractures, properly so called, occur both in the flat and long bones. Permanent depressions of the cranium produced during birth are usually, and according to some authorities always, accompanied by slight fracture. So, too, in the bones of the adult cranium

[1] Traité des Fractures et des Luxations, 1847, plates.

fracture may be confined to either table, or to the diploë. Partial fracture of the ribs occurs at all ages; and Adams drew attention to its frequency in the neck of the femur.[1] The vertebræ bend up to a later period of life than other bones, because they contain more animal matter.[2]

Bending, or incomplete fracture, or, as known by its best name "green-stick" fracture, of the shafts of long bones is by no means rare in childhood, especially between the ages of five and fifteen. It has been observed in all the long bones, but most frequently in the forearm. Next in order of frequency come the clavicle, the femur, and tibia. In the bones of the forearm singly, in the humerus and fibula, it is rare. It may be doubted whether simple bending without fracture ever occurs in the human subject; it has only been seen as the result of experiment in the soft bones of very young animals. The usual form of injury is well shown in the accompanying illustration, copied

Fig. 83.

Bending of clavicle. Green-stick fracture of the clavicle. St. George's Hospital Museum.

from Holmes's Diseases of Children (Fig. 36, p. 234). The fibres on the convexity of the curve have given way, those on the concave side being unbroken. There is no displacement of the fragments, which, indeed, rarely occurs, and the periosteum usually remains untorn. With few exceptions, a bent bone recovers its shape after a few weeks, or perhaps months, by its own elasticity, aided by compression. The possibility of partial fracture in the adult has been called in question by many. Jurine, however, distinctly affirms that he has seen such cases; and that it may be readily produced on adult bones in the dead subject is proved by the experiments of Meding,[3] Campaignac, and Malgaigne.

[At the Pathological Society of London, Jan. 31, 1880, Dr. E. H. Bennett "showed an example of incomplete fracture of the bones of the forearm ('green-stick fracture') in a tall, strong man of twenty-one years of age. The arm had been caught in machinery in rotation, and the whole body had been whirled through the air by the entangled arm. One fracture of the ulna, two fractures of the radius—all incomplete, and of the first form of the 'green-stick' fracture of Professor R. W. Smith —had occurred. The fractures had been reduced during life, and that of the ulna rendered complete, while the radial fractures had been straightened without completion. The patient sank from secondary arterial hemorrhage," probably from the other injuries sustained.[1]]

3. The separation of a splinter, leaving the remainder of the bone intact, is a rare accident. It can only be effected by a wounding instrument, as a sabre or ball; hence it is necessarily compound. The cranium and prominent points of bone are most exposed to this peculiar form of injury. Rarely, indeed, are the shafts of long bones so fractured.

4. Perforations, also, are necessarily connected with an external wound. All bones are liable to this form of fracture, which is attended by this peculiarity, that the body which inflicts the injury may remain in the bone, the perforation being complete or incomplete.

IV. The complications of fractures comprise all concomitant injuries to organs other than the bones themselves, and all general affections. Only one distinct variety is included under this head: viz., fractures which extend into a joint. These, unless produced by a ball or penetrating instrument, are usually simple.

Diagnostic symptoms.—The symptoms of fracture are rational and sensual [or physical]. The rational symptoms are the evidences of injury to internal viscera, resulting from the fracture of the bones which inclose any of the large cavities. As evidences of fracture they are rarely of much value, except in those cases

[1] Dublin Journ. of Med. and Chem. Science, vol. vi., 1835, pp. 220 *et seq.*

[2] Lettsomian Lectures on the Phys. Const., Diseases, and Fractures of Bones, by John Bishop, 1855. This author assigns teething, and the quantity of phosphate of lime which that process requires, as one principal cause of the softness of the bones up to the age of four.

[3] De Regeneratione Ossium per experimenta illust., Diss. Inaug. Lips., 1823.

[1] Med. Times and Gazette, Feb. 14, 1880.]

where their gravity indicates that the fracture itself is of secondary importance to the internal complication. The sensual symptoms are of two kinds: certain, pathognomonic, or unequivocal; and uncertain, or equivocal. The unequivocal signs are four: the sharp crack heard by the patient at the moment of fracture, unnatural mobility of the fragments, deformity, and crepitation. The equivocal symptoms are three: pain, swelling, and loss of power.

In the great majority of cases the attention of the patient is distracted by so many circumstances at the moment of fracture, by the sudden pain, by alarm, and by surrounding noise, that he is not conscious of the slight crack produced by the snapping of the bone. It is generally, however, heard unmistakably in cases of fracture, at least of long bones, by muscular contraction; or when the accident happens in a quiet place, as in bed, or during the efforts to reduce a dislocation. It is, when heard, a valuable sign; the only thing with which it would be possible to confound it being the sudden snap of a tendon, or perhaps that of the displacement or rupture of a ligament during dislocation.

Mobility of the fragments is, of course, a necessary condition both of deformity and crepitation. But it is frequently diagnostic without the latter accompaniment, as in fracture of deep-seated bones, or when there is separation of the fragments. The most readily detected and most conclusive test of fracture of the fibula is, mobility of the lower fragment without the upper. It frequently occurs, however, that this symptom is either absent, or not sufficiently decided for the purpose of diagnosis. In many fractures of short and flat bones, as of the spine or pelvis, and in comminuted fractures, it can scarcely be said to exist. The same is the case with some fractures of a single bone, supported by a neighbor, where one acts as a splint to the other; and in dentated and impacted fractures. And in all fractures in the neighborhood of joints its interpretation is interfered with by two causes—the difficulty of holding the smaller fragment, and the natural mobility of the joint. Lastly, it is a test not to be relied on as applicable to the ribs, on account of their elasticity.

Of all the symptoms of fracture, deformity is the most valuable, because it is the one which gives the greatest amount of information. It is not, of course, present in every case, being often prevented by the shape or connections of the bone broken; as in fracture of the broad upper end of the tibia, or ulna; of one of two parallel bones; of the sternum; of the face, or cranium.

There are five varieties of displacement, having reference, 1. To the diameter of the bone, *transverse* or *lateral;* 2. To its length, *shortening* or *riding;* 3. To its axis, *angular* displacement; 4. To its circumference, *rotation;* and 5. To the contiguity of the fragments, *direct separation.*

Transverse displacement may take place in any direction, though fractures of the same bone preserve, for the most part, a certain degree of uniformity in this respect. Its amount is equally variable. In oblique fractures it is more or less inevitable. When complete, it is necessarily accompanied by shortening, unless this be prevented by the support of a neighboring bone. In fracture of superficial bones it is readily both seen and felt; and in very oblique fractures, especially of the tibia, the projecting fragment threatens to, and in some instances actually does, pierce the integuments. In more deeply seated fractures it may be ascertained, though not so readily, by tracing the bone with the fingers, and by noting the increase in the diameter of the limb at the seat of fracture. Longitudinal displacement is present to a greater or less extent in all oblique fractures. In all cases it is the inferior fragment which is displaced. Although, as a rule, it implies the addition of transverse displacement, this is not the case in impacted fractures. In them the lower fragment is generally driven into the upper; but the reverse occasionally happens in the neck of the femur. In most, if not in all of these cases, there is more or less angular displacement, a species of deformity rarely absent from the fractures of long bones, being readily produced by the mere weight of the limb, and which, when distinctly marked, is in itself sufficient evidence of the nature of the injury. Rotatory displacement is also effected by the movement of the lower fragment. It is especially characteristic of fractures of the femur, though not confined to them; and is recognized by comparing the positions of the processes of the broken bone with their natural relations. Displacement by separation takes place in nearly all (transverse) fractures of the patella, olecranon, and os calcis, in all of which it is produced by muscular contraction. It is rarely seen elsewhere; but in some fractures of the lower end of the fibula, the lower fragment may be drawn away from the upper by rotation of the foot; and in severe fractures of the skull there may be an interval between the fragments, or between two bones separated at a suture.

The causes of these various kinds of displacement are four: the continued action [or effect] of the violence which caused the fracture; the weight of the limb, or of the body; the subsequent ac-

tion of other external forces; and, lastly and principally, the influence of the muscles. The original violence may produce any of its varieties, with few exceptions. It is the sole cause of impaction, and the chief agent of angular displacement. Most indirect fractures of the lower extremity, and those of the upper which are caused by falls on the hand, suffer from the weight of the body. This, indeed, it is which renders many indirect fractures compound. Angular and rotatory displacement are to a great extent caused by the weight of the limb. It is not often that any subsequent violence is brought to bear on the position of the fragments, except through the imprudence of those who carry the patient, or of himself during delirium. The most powerful and most unfailing cause of displacement is muscular action. This is twofold: healthy, tonic contraction, and spasmodic. The influence of the former is usually heightened by semi-voluntary movements of the patient, provoked by the efforts at reduction. Although muscular contraction has a large share in the production of all the forms of displacement, it is the special agent of shortening. The muscles connected with the lower fragment are answerable for this result, so that in the great majority of cases it is this fragment which suffers displacement, and is to be brought into contact with the upper; the apparent rising of the latter being due solely to the displacement of the former. But in fractures near to the upper end of a bone, transverse displacement may be effected by the muscles attached to the upper fragment, as happens in fracture of the femur immediately below the trochanters, and of the neck of the humerus. In children the fragments usually undergo less displacement than in adults; partly because, on account of the elasticity of their bones, their fractures are more irregular; but principally because the periosteum is often not completely torn across, and the patients are much less exposed to the after causes of displacement.

In examining for displacement, the only sources of fallacy are the remains of some former injury, which must be learnt by inquiry, and the presence of splinters, or of effused blood; which last may mask, or simulate, a bony ridge. The sensation imparted by coagulated blood has more than once led to error in the examination of the cranium for fracture; and a similar condition is occasionally met with over other superficial bones.

Crepitation may be recognized in most cases of fracture, and is a symptom which cannot mislead. In splintered and comminuted fractures, and when the fragments are loose, the least motion or pressure suffices to determine it. Generally, however, some care and art is requisite for the purpose; the lower fragment being moved while the upper is fixed by a firm grasp, or both fragments being simultaneously moved in opposite directions. In doubtful cases, or where the limb is large, the examination is facilitated by confiding the upper fragment to an assistant, and exploring the supposed seat of fracture with the fingers during the above movements. In certain fractures in the neighborhood of joints, as the hip or shoulder, rotation of the limb, or flexion and extension, answers the purpose better than lateral movements. If there is any interlocking of the fragments, they must be separated by extension before they can move upon each other. In partial fractures no crepitation can be produced till the bone is straightened, and the broken surfaces brought into contact with each other, and not always then. In many fractures of the ribs, the necessary movements can only be effected by making the patient cough. To facilitate the discovery of crepitation in obscure cases, M. Lisfranc[1] advocated the use of the stethoscope, which may be occasionally resorted to with advantage in the examination of fractures of the ribs, pelvis, or shoulder, or when there is excessive swelling. But in most cases it is unnecessary and cumbersome.

In many instances this symptom is altogether wanting: in all impacted, and many dentated fractures; when the fragments are separated, as in fracture of the patella; when they ride (in which case it can only be obtained after elongation); also in some fractures of a single bone in limbs provided with two, when its neighbor prevents the necessary movements; or when a clot of blood or bit of muscle intervenes between the fragments.

[Perhaps it may be well here to protest against the needless suffering often inflicted by surgeons in "developing" and demonstrating crepitus. Once clearly felt, no further testing for it is needful, unless in the rare cases, where it serves as a guide in locating the precise seat and direction of the breakage.]

A sound more or less resembling crepitation may be caused by emphysema; by the rubbing of tendons in their sheaths, or of the inflamed and roughened surfaces of a joint, aided, according to Sir A. Cooper, by the altered state of the synovia. This sound, as compared with crepitation, is slight, dull, and creaking, and may be produced by simple pressure of the joint; and the rubbing of tendons is analogous to it, and jerking. In the discrimination

[1] Mém. sur de nouvelles Applications du Stéthoscope, par M. J. Lisfranc. Paris, 1824.

of these sounds the stethoscope has its chief use.

The remaining symptoms, pain, swelling, and loss of power, being common to other forms of injury, are of little or no value for the purpose of diagnosis, except as indicating the precise seat of fracture, or, in some instances, the nature of its cause, whether direct or indirect. However, if no large vessel is torn, the amount of ecchymosis is a good general guide to the extent of the mischief, both to the bone and soft parts. In doubtful fractures, too, pain may acquire importance by its persistence, or even increase, long after the subsidence of ecchymosis and inflammatory swelling, especially if accompanied by acute though circumscribed tenderness.

There are two forms of injury which may be mistaken for fracture—a severe bruise, and dislocation. In some instances of the former it is not possible to obtain conclusive evidence of the nature of the case till after the subsidence of the swelling. There is seldom much difficulty, however, in distinguishing dislocation from a fracture near the joint. In the former the natural movements of the joint are impeded, and the bones are more or less fixed in their new position; they offer considerable resistance to reduction, but, when reduced, remain so. In fracture, besides the crepitus, when it exists, there is preternatural mobility, and the length and shape of the limb may be readily restored by extension, but only so long as this extension lasts. In the fractures near superficial joints, as the elbow or wrist, a careful examination of the relations of the most prominent processes precludes the possibility of error.

[The diagnosis between fracture and luxation is obviously of the utmost importance, since in the latter case prompt reduction would be indicated, and the lapse of time before the discovery of the true nature of the case might place it beyond remedy.]

Besides the above general symptoms, variously combined in different cases, there are others peculiar to certain forms of fracture. Of course in compound fractures there is little room for uncertainty, because the nature and extent of the injury is exposed to the view and touch. When a compound fracture extends into a joint, there is commonly an escape of synovial fluid. Care must be taken not to mistake for this the yellow drops of fat which ooze from the subcutaneous tissue, especially in the neighborhood of the knee: it is recognized by the color, synovia being white. At a later period these fractures are accompanied by the symptoms of inflammation of the joint itself.

Two only of the varieties of fracture, from certain peculiarities in their history and symptoms, require especial notice—incomplete fractures and fissures. In cases of incomplete fracture in children, the limb is distinctly bent, and offers considerable resistance to reduction. There is little or no absolute shortening; indeed the convex side is lengthened. When the bone is straightened, or nearly so, slight crepitus may sometimes, but not always, be distinguished during rotation. In two or three days, but not before, a slight swelling may appear at the part, and about that time the bone sometimes gives way altogether from subsequent yielding of the periosteum, especially if splints have not been applied from the beginning. The child always evinces pain, and unwillingness to use the limb. The history of violence, generally a fall, and the age of the patient, assist the diagnosis. Occasionally, but not often, a slight transverse fissure can be felt through the skin.

It is very rarely that a simple fissure of a bone can be recognized at first. If it extends into a joint, there may be slight lateral movements of the fragments on one another; and the subsequent inflammation of the joint, especially if severe and obstinate, will justify suspicion.

Treatment.—Immediately after the accident there are certain minor much-neglected precautions to be taken, the observance of which materially affects the comfort and well-being of the patient. Many fractures of the lower extremities are seriously aggravated by his own impatient movements, or by the ignorance and thoughtlessness of attendants. Frequently is a simple converted into a compound fracture, the soft parts are bruised and lacerated, and the foundation laid for violent inflammation and spasms. By small care such accidents may readily be avoided. The patient should be placed on a horizontal support, whether a door or shutter, or a proper litter, and the foot of the injured limb should be tied to the other to prevent its eversion by its own weight. Conveyance in a carriage of any kind is to be condemned. Wherever the nature of an employment engenders many accidents of this kind, special apparatus should be provided. In military practice, litters are indispensable; and M. Vallat contrived an ingenious kind of box to be used in mines, where, from the narrowness of the shaft, it is impossible to preserve the horizontal position. Wathen, too, invented an instrument to fix and extend the fragments during conveyance;[1] but the utility of such instruments is, of course, limited.

[1] The Conductor, etc., by J. Wathen, 2d edit., Lond., 1767.

No examination of the fracture should ever be made till the patient occupies that position in which he is intended to remain during the treatment. All voluntary movements on his part must be discouraged during the undressing and subsequent examination. In a very few cases, especially in children, and when there is excessive pain and ecchymosis, it will be found advisable, or even necessary, to place the patient under the influence of chloroform [or ether] before a proper examination can be made, or reduction effected.

The treatment presents three indications: reduction of the fragments to their normal position; their maintenance in this position till consolidation is effected; and the counteraction of unfavorable constitutional symptoms and complications.

If there is no displacement, or if, by reason of ecchymosis, or of the depth of the fracture, it cannot be ascertained; or if, although distinctly recognized, it cannot be removed, as in fracture of the spine, any attempt at interference would of course be absurd. The means of reduction necessarily vary with the nature of the displacement. For angular or rotatory displacement, or simple separation, they are sufficiently obvious. But the rectification of shortening by extension presents greater difficulties. It may be made either by the hand or by the assistance of apparatus. French writers speak of the common use of lacs and pulleys for this purpose; but there are serious objections to their employment. The force used in effecting reduction should not greatly, if at all, exceed that which can be permanently maintained: and if the present obstacles to that operation refuse to yield to milder methods, it is better to defer it than to run the risk of aggravating the existing injury by violence.

During extension the upper fragment must be fixed (*counter-extension*) either by the operator himself or by the hands of assistants, care being taken to exert equal force in each direction. For the application of extension, whether during reduction or permanently, Boyer lays down five rules, of which at least four are essential to success: 1. To avoid compressing the muscles which pass over the fracture, such compression being calculated to irritate them, and excite them to increased resistance. This rule is not always regarded, and is the least important; it was, however, one of the objections to some old forms of thigh-splints, that they confined the entire muscles of the limb. 2. To distribute over as large a surface as possible the extending and counter-extending forces. The parts to which these forces are to be applied vary in different cases. The old practice, under Petit's authority, was to grasp the fragments themselves. Boyer, Desault, and others, however, thought that not only would the muscular resistance be diminished, but greater power of extension would be obtained by applying the forces to the contiguous parts of the limb. But, in truth, neither doctrine can be exclusively adhered to. In most cases convenience is the best guide. The grasp must be laid upon that part of the limb which offers the most secure and most effective hold, such as the condyles of the humerus in fracture of that bone, and the foot in fracture of the femur. Except on this principle, no increase of power is, or can be, gained by applying it at a distance from the fractured bone. [On the contrary, there is a loss.] 3. To make the extension in the direction of the natural axis of the bone. 4. To practise it slowly and gradually, avoiding all jerks and sudden violence, which not only increase the spasmodic resistance of the muscles, but may even lacerate both them and other soft tissues. 5. To protect from undue pressure all parts on which the forces act, and to equalize the compression of the various parts of the apparatus employed.

As soon as sufficient extension has been made, the ends of the bone are to be placed as nearly as possible in their natural relations (*coaptation* or *setting*). This is effected by bringing the lower fragment to the axis of the upper, which remains fixed. In the fractures of subcutaneous bones it is generally easy to see when the extension is sufficient, and coaptation perfect. Not so, however, when the fracture is concealed by extravasation or a thick mass of muscle. Sometimes, indeed, the sudden restoration of the outward form of the limb is a sufficient guarantee of the mutual adaptation of the fragments. Failing this guide, recourse must be had to measurement, the opposite limb being taken as the standard of comparison. Should there be any deformity of the opposite side, resulting from a previous mishap, advantage may be taken of the present accident to equalize the two extremities.

But when extension is complete, it does not always follow that coaptation is easy. The sources of difficulty are three: irregularity of the fracture; the presence of splinters; and the interposition of soft parts. In the case of a dentate or impacted fracture, it is necessary to extend the limb beyond its natural length, and then, by variously-directed manœuvres, to coax the fragments into each other. Partial rotation will sometimes effect the object. But if the displacement resist all

reasonable efforts, it is better to suffer the deformity to remain (unless it is excessive, or is likely to interfere with the performance of the functions of the limb), than to run the risk of producing serious mischief by violence. The same may be said of those cases in which reduction is prevented by the peculiar position of a splinter, in which much manipulation would be highly dangerous. Even if the splinter is superficial, unless it is so prominent as to render its ulceration through the skin a matter of certainty, it should be left alone. Only in the latter case is it justifiable to extract it. When any soft parts intervene between the fragments, they are generally released by the means indicated above. If they are not, M. Laugier has proposed to divide them by subcutaneous incision.[1] In the one case of fractured femur, however, in which he tried it, he not only failed to effect reduction, but he created an abscess, which occasioned the death of the patient. It is far better to trust to the probability of the absorption of the intervening tissue by the pressure of the fragments.

As a general rule, reduction is to be effected immediately after the accident. Some surgeons, it is true, recommend that it be delayed for three or four, or even ten or twelve days,[2] till all fear of inflammation be past. No reparative process being yet commenced, the position during that period does not affect the final result; and the difficulties of reduction are, according to them, scarcely, if at all, increased by the delay. Nevertheless, immediate reduction has great advantages. It restores the patient to comparative comfort, and diminishes the chance of spasms and other evils resulting from the mal-position of the parts. Moreover, it is not true that reduction at a later period is equally easy. Not only are the fragments more or less fixed by surrounding effusion, but the muscles, accustomed to a new position, offer greater resistance to a change. There are, however, two classes of cases in which immediate reduction is either impracticable or inadvisable. If there has been from the first excessive ecchymosis, or if when the patient is first seen much inflammation has already supervened, the attempt may be not only unbearable, but highly injurious, causing laceration of the soft parts, spasms, convulsions, or even tetanus. The inflammation must be combated by the ordinary means, and reduction deferred till it is fully subdued. Still more serious is the obstacle presented, in the other class of cases, by excessive spasm. Spasm is a very constant accompaniment of fracture, especially if in the neighborhood of a joint; so constant, indeed, as to be considered, in doubtful cases, almost diagnostic. Its degrees are variable, from slight nocturnal twitchings, ceasing after the second or third day, to uncontrollable oft-recurring contractions, accompanied, it may be, by general convulsions. The severer form of continued spasm is far less frequent than the intermittent. The causes of spasm are three: the irritation of the fragments, injury to nerves, and the altered position of the muscles themselves, whether increasing or diminishing their habitual tension. If they are much bruised, the spasm may be less severe at first than at a later period, after they have recovered their functions. The defeat of spasm by violence is hopeless. Laceration of the muscles, or even of the vessels will be the only result. Boyer induced fatal hemorrhage by violent and abortive efforts to reduce a fracture of the femur.[1] In other cases such efforts have led to convulsions or tetanus.[2] Still more hopeless will be the attempt if inflammation is superadded. The two main remedies to be relied on are position and energetic antiphlogistic treatment. For pure and simple spasm full doses of opium are of great service; but if it is combined with inflammation, they only tend to mask without abating the evil. The same may be said of the inhalation of chloroform [or ether], but it is necessary to give it repeatedly in small quantities, so as to sustain its narcotizing influence; for, in severe cases, the spasms will return, whenever its effects pass off, for many days. The limb should be placed in the position of semiflexion, relaxing the muscles to the utmost. But when all these means fail, recourse may be had to subcutaneous division of the opposing muscles, an operation which has hitherto been practised only in the lower extremity. (See INJURIES OF THE LOWER EXTREMITY.)

[Modern surgery has developed two mechanical means of overcoming muscular spasm in these cases, which rarely fail. One is the use of elastic bands, and the other the attachment to the limb of a cord running over a pulley, and sustaining a suitable weight. The methods of employing these will be given in detail in connection with special fractures.]

In the reduction of incomplete fractures considerable difficulty may be experienced. Immediate complete reduction is, indeed, out of the question. Usually, however, the curve yields partially, to be entirely removed only after many days, or weeks,

[1] Bull. Chirurg., part ii., p. 253.

[2] Sir S. Hammick recommends a fractured femur to be left till the tenth or twelfth day.

[1] Gaz. des Hôpitaux, 1844, p. 535.

[2] Malgaigne, op. cit., pp. 198, 284.

by the pressure of splints. But if from irregularities of the broken surfaces even this partial yielding cannot be obtained, and the mal-position interferes materially with the functions of the limb (such as pronation and supination in curvature of the forearm), the fracture must be rendered complete in order that it may be reduced.

After reduction is effected, the whole treatment is directed towards obviating the influence of those causes which tend to reproduce displacement. Those causes are three: 1. The weight of the body, the limb, and its coverings. 2. The action of the muscles. 3. The movements of the patient. They are to be obviated by position and apparatus. But whatever be the position adopted or the apparatus employed, it is essential that the basis of support for both the body and limb be firm, unyielding, and equable. Accordingly, for fractures of the lower extremity, soft beds are inadmissible. The best is a horse-hair mattress, resting on a wooden frame, or on a board extending from the hips downwards. It is also essential, whatever kind of apparatus be used, that every part of the limb be equally supported, otherwise its own weight will reproduce displacement. The apparatus must be adapted, by its own shape, or by the use of pads, to the inequalities of the limb. All pressure on prominent points must be avoided.

Formerly it was the custom to apply some kind of cerate immediately to the fractured limb. It was supposed to increase the support afforded by the bandages and splints; to repel inflammation; and, as a local sedative, to diminish pain. The practice, however, has long been discontinued. Not only was it altogether useless, but the fat checked and retained the natural secretion of the skin, and becoming rancid, was a frequent cause of pruritus and eruptions.

The apparatus for retention is very various. It includes, 1. bandages; 2. splints; 3. junks; 4. numerous forms of hyponarthecic apparatus; 5. apparatus for maintaining the flexed position; 6. suspensory apparatus; 7. special means of maintaining permanent extension; 8. immovable apparatus.[1]

In fracture of the extremities, various advantages have been assigned to the use of circular bandages beneath the splints, *i. e.*, immediately to the limb. They have been supposed to contribute to the support of the fragments; to diminish œdema, and promote absorption of effusions; and to abate the irritability of the muscles by the equable compression of all parts of the limb. For support, however, they are altogether superfluous; their influence on spasms is questionable; their pressure is often unbearable and injurious, and they remove from view the seat of fracture. They are of service only if the splints occasion œdema (which, however, if properly applied, they rarely do). If they are used, it is necessary to examine the limb frequently, lest hidden mischief supervene. The early application of circular compression has, on several occasions, given rise to fatal gangrene, which has not been manifested by pain or any other symptom till too late. The many-tailed bandage, or the bandage of Scultetus, may sometimes be useful in inflamed and compound fractures for the retention of dressings, the absorption of discharge, and the approximation of the sides of the wound.

Most fractures may be conveniently treated with splints. Pasteboard splints, which admit of being accurately moulded to the limb, may be used for nearly all fractures in children, and for those of the phalanges in adults. In other cases the support they give is insufficient. Metal splints are for the most part cumbersome.

[A great point is to have the splints accurately adapted in each case—and the ability to effect this is an important element of success in this branch of surgery. Wood may generally be cut into suitable shape; but it perhaps easier to use moulded splints, of leather, felt, gutta percha, or shellac cloth. The starched or plaster bandage, or gummed paper, may be effectively used in dexterous hands. And with a proper pair of shears, thin sheets of tin or zinc may be cut into splints which will answer admirably. Woven iron-wire splints are highly recommended by some.]

The length of splints must vary according to the purpose which they are intended to answer, and the limb to which they are to be applied. Their proper use is to preserve steadiness of the fragments without compressing the actual seat of fracture. Pott accordingly lays down a rule that they are to include the joints above and below. In fractures of the leg this is to be universally observed, because all kinds of displacement are thus obviated. But the rule is not absolute. In fracture of the femur, the prominence of its condyles, and the thickness of soft parts, would annul the efficacy of splints so placed. The same is the case with the humerus; and in fractures of the upper extremity generally, flexion of the joints is a positive bar to the application of the law. But splints confined to the length of the shaft of the bone have less power

[1] For the description and use of the various apparatus, see the articles on the special fractures.

over angular displacement, and little or none over rotation. Whenever the movements of a joint would derange the fragments, that joint must be confined by the splints. This is especially the case with fractures of the phalanges, and those in the neighborhood of the joints.

A good occasional substitute for splints is found in junks, which, inclosing three sides of the limb, on all of which they make equable compression, sometimes succeed in overcoming displacement, even obstinate riding, where splints fail.

At sundry times various kinds of circular splints have been invented, so made as to surround not only the fractured limb, but the adjoining part of the trunk. But as they are costly and inconvenient, and answer no purpose which cannot with some pains be attained by more simple means, they have rapidly fallen into disuse.[1]

By hyponarthecic apparatus is meant that which merely supports the limb beneath, leaving it free and exposed to view elsewhere. The indications aimed at in its employment are two: position (many of its forms having special arrangements for flexion), and exposure of the limb for examination and the application of dressings. For the latter object they are indispensable in the treatment of inflamed and compound fractures, being the only forms of apparatus which can reconcile the proper care of the wound with firm retention of the fragments. In other cases their utility varies according to the kind of fracture to be treated. It is manifest that, unless combined with splints, they are capable of opposing but a slight obstacle to lateral or angular displacement. But, on the other hand, it is easier to maintain extension with them, and they are recommended by simplicity and facility of application.

The great mass of apparatus recommended by different authors bespeaks alike the great facility with which some fractures are treated, and the insuperable difficulties presented by others. In these latter a selection can only be made by strict attention to the indications to be answered. These are commonly but two: fixation of the fragments, and their maintenance in apposition by opposing the particular kinds of displacement present. In some cases there is a third: exposure of a certain part of the limb, for the treatment of local complications. The greatest difficulties are created by shortening, and numerous methods of maintaining permanent extension have been devised. The most simple and most common is direct traction, as provided for in Desault's thigh-splint, and in many forms of hyponarthecic apparatus. The use of a weight and pulley for this purpose, formerly in vogue, has been of late reintroduced at University College Hospital and elsewhere. A second mode of extension is the conversion of a contiguous bone into a lever, as the humerus in the treatment of fractured clavicle, or the femur in fractures of the leg. And, inasmuch as shortening cannot occur, except in impacted fractures, without producing some degree of lateral displacement, so the lateral pressure of splints or junks, by the obstacle which it presents to the one, is often sufficient to counteract the other. This is the feeblest mode of producing extension; nevertheless, in most fractures of the upper extremity, and in many of the leg, no other is required. Only care must be taken that the lateral pressure be not carried to an injurious extent. In all cases of very oblique fracture, where the fragments readily glide upon one another, union will be greatly accelerated by firm lateral pressure either by splints, pads, cravats, junks, or by Amesbury's apparatus. There are cases, however, in which great obliquity and frequent spasms, aided perhaps by great muscular power and irritability of the patient, or by tenderness of the skin, precluding the employment of much pressure, or necessitating frequent change of apparatus, will render all these means nugatory.

In compound fractures the difficulty of retaining the fragments has been occasionally met by ligature or suture of the bones. Ligature by brass, silver, or lead wire has been very rarely adopted.[1] Suture is more feasible and more efficacious; but not often necessary, nor altogether free from danger.[2]

It is seldom possible to obtain absolute immobility of the fragments. Neither is it essential, though M. Bonnet in France, and Amesbury in this country, have insisted on its necessity, and the insufficiency of ordinary apparatus (vide *infra*, p. 505). It is usually enough to warn the patient to restrain his own movements during the first few days. Only in the cases of children, of restless, delirious, and maniacal patients, are greater precautions necessary. In children immovable apparatus may safely be used at an earlier period than in adults; but, on account of the delicacy of their skin, greater care is necessary to avoid tight pressure.

[1] For an account of such machines, see Wiseman's and Heister's works. Also Lafaye, in Mém. de l'Acad de Chir., t. ii., p. 403; and Bonnet, Mém. sur les Frac. du Fémur, etc., in Gaz. Méd., 1839.

[1] Icarte, "Lettre en réponse à M. Pujol," in Jour. de Méd., 1775, p. 164.

[2] Laloy, "De la Suture des Os," etc., Thèse inaug., Paris, 1839.

In consequence of their habits, the apparatus must be protected from urine, etc. [This may be done by means of waxed paper, or by varnishing the exposed portions of the splints with an alcoholic or ethereal solution of shellac.] In cases of delirium it is sometimes absolutely essential forcibly to restrain the patient by strapping him, as well as the injured limb, to the bed. In such cases some form of immovable apparatus should be applied as early as possible.

In all cases the fracture must be examined from time to time—to see that coaptation is not disturbed, necessitating readjustment. This can usually be done without deranging the apparatus. But, whenever any kind of circular apparatus is employed, it must be removed for the purpose after all swelling has subsided, and before union has too far advanced, viz., after the lapse of from one-half to two-thirds of the time requisite for consolidation.

When the period ordinarily required for union has elapsed, a careful examination of the limb must be made before it is allowed to resume its functions. Sometimes, even when examination by the hands gives an impression of firmness, yet the incompleteness of union will be manifested by the supervention of pain during use of the limb, in which case the treatment must be resumed. After the union of a simple fracture, there is rarely much impediment to immediate freedom as soon as the apparatus is removed. Even in fractures of the lower extremity, the liberty enjoyed by the patient during the latter part of the treatment gives him confidence and earlier use of the limb, besides diminishing the risk of œdema. [For this purpose it is a good plan to gradually take away the supporting apparatus, so that the limb may be left more and more to itself.] But the restoration of the functions may be impeded by two causes: atrophy of the limb, and stiffness of the joints.

Atrophy is generally the consequence of prolonged suppuration: but occasionally it proceeds from the excessive pressure of apparatus in the early treatment [which should therefore be avoided]. It gradually yields to tonics, position, and gentle exercise of the atrophied muscles.

Stiffness of the joints arises from two causes: inflammation, when the fracture has been in their neighborhood, and long-continued immobility. Even when the joint is in no degree implicated in the fracture, long confinement in one position, especially extension, induces partial immobility of the joint. This effect is due mainly to a tonic contraction of the ligaments, and, in a minor degree, of the tendons. The muscles also become more or less retracted, and lose both volume and power; but their influence in fixing the joint is much less than that of the ligaments. It also appears, from certain observations of M. Tessier,[1] that long-continued fixed extension of a joint is capable of setting up in it (by the mutual pressure of the articular surfaces) a real inflammation, with its consequences, viz., formation of false membrane, destruction of the cartilage, and partial anchylosis. There is but one mode of avoiding this disastrous result in all cases in which it is threatened; viz., gentle exercise of the joint from the earliest possible period, that is, from the earliest period at which such exercise will not interfere with the union of the fracture. The observance of this rule is of especial importance in fracture of the upper extremity; the effects of anchylosis being there most disastrous. [Hence the great importance of frequent passive motion from a very early period. The fracture can be firmly grasped, and the joint moved freely; but if the latter is once allowed to stiffen, there is great risk of disturbing the union by the force required to free it.] The treatment may be assisted by frictions, emollients, and douche baths; but these are to be regarded as secondary to constant exercise.

At any period, till the new bone has acquired perfect solidity, it is liable to bend or break from the weight of the body, or from blows or falls. This accident is not rare. Accidental bending of the femur has been seen so late as the 135th day,[2] and refracture eight or eighteen months, and even two or three, and in one case seven years after the first;[3] but in these extreme cases union has been delayed, or, from deformity, has never been strong. These secondary fractures unite more readily than the first, from the spongy nature of the new bone; and curvature readily yields to pressure.

Treatment of compound fracture.—Although the rules of treatment laid down for simple fracture are equally applicable to compound, yet the latter present certain special points for consideration, viz., the reduction of a protruding fragment; the treatment of splinters and loose pieces of bone; and the mode of dressing the wound.

It is usually the upper fragment which protrudes. When the wound in the skin has been made by the pressure of the fragment itself, it is commonly small, and occasionally girts the bone tightly. The difficulty of reduction is in proportion to

[1] Gaz. médicale, 1841, pp. 609, 625.

[2] Guillon, Thèse inaug., Paris, 1820.

[3] Œsterlen, op. cit., obs. 21–30; and Malgaigne, op. cit., p. 326.

the size of the wound, the length of the protruding bone, and the degree of accompanying spasm. If reduction cannot be effected by moderate extension and dexterous manœuvring, the wound must be enlarged. But although this measure is attended with far less danger than violent efforts of extension, it is yet to be adopted as sparingly as possible. The enlargement is to be made in that direction in which the smallest additional division will give the greatest amount of freedom. This will usually be in the axis of the bone. If, on account of the length or sharpness of the protruding piece, even this is not sufficient, the end of the bone, so far as necessary, must be sawn off. In compound, as in simple fractures, excessive spasm may render it necessary to postpone complete reduction, but under no circumstances may the bone be allowed to remain protruding.

If the bone is splintered or comminuted, some judgment is required in determining what pieces to remove and what to leave. Splinters are of three kinds. Some, though split away from the bone, are still connected to it in their whole length by the periosteum, to which they are firmly adherent. These, in young and healthy subjects, are not to be touched; they become reunited to the bone; they rarely die. But in the old, and in cases of gunshot wound, it is prudent to remove them. Others are completely torn away from the bone, and are found lying loose among the surrounding tissues. All these are to be carefully removed, whether they carry with them their periosteum or not. If, being at a distance from the fracture, they are not easily reached through the wound, a counter-opening may be made for the purpose. A third set are partly adherent, partly not. These may reunite; more commonly they partially die, in proportion to the injury to their periosteum, and keep up for a long period—for months, perhaps for years—a succession of abscesses, retarding, or entirely preventing, union, greatly prolonging the danger, and involving, it may be, the ultimate loss of the limb. They must, therefore, so far as is practicable, be removed. But some allowance may be made for differences in their position. If they are at the bottom of a deep wound, and difficult to reach, it is the better and less hazardous course to make no attempt at interference. Such attempts have resulted in gangrene and death.[1] On the other hand, should the fracture be in the neighborhood of a joint or of a visceral cavity, on no account may they be suffered to remain. They are even more injurious there than elsewhere. In the treatment of these fractures the most perfect clearance of all loose fragments is the first requisite. The bones of the face, however, except the lower jaw, are so well supplied with vessels, and their repair is so energetic, that much more latitude is allowable in dealing with splinters in their fractures than in others, especially as it is more than usually desirable to avoid deformity in that region. All sharp projections of the splinters which are left, or of the fragments themselves, should be nipped off; they may wound or lacerate the soft parts, or open some vessel. For the purpose of removal (which should be done by the fingers in preference to instruments), it may be necessary to enlarge the wound. In all cases, all tendinous or membranous structures which obstruct the removal, or unduly confine or strangulate the soft parts during the subsequent inflammation, are to be freely divided.

If there is hemorrhage, it is to be treated on the same principles as in other wounds, the employment of pressure being, however, somewhat limited by the state of the bone. All projecting threads of lacerated muscle or tendon should be cut away. Then the wound is to be dressed; and it is, perhaps, in cases of this class that the antiseptic treatment introduced by Mr. Lister has achieved some of its greatest triumphs. It must always be remembered that the primary object is the conversion of the fracture, if possible, from compound to simple. This is of so great importance, that it should invariably be attempted. If the attempt is only partly successful, some advantage is gained. The end may be attained in simple cases by the old methods of dressing with some unirritating plaster, or lint dipped in blood. Some surgeons prefer the use of Dr. Richardson's "styptic colloid." But there can be little question of the great superiority over all these means of Lister's treatment, under which, when applied with the necessary care and precautions, many very severe and dangerous fractures have been speedily brought to a condition of comparative harmlessness.

There are but two classes of cases in which sutures are admissible; first, when an endeavor is made to save a limb, as a finger or hand, which is nearly divided across; and, secondly, when the skin is peeled off from the underlying tissue. In all other cases they must be regarded as useless irritants.

As soon as it is clear that the effort at primary union has failed, the first dressings are to be removed, and the wound to be treated according to its condition, as

[1] See a case related by Bessière, in which an attempt was made to remove a ball and splinter from between the radius and ulna; "Des Complic. des Fractures," Thèse inaug., 1851.

though it were uncomplicated with fracture. For the fracture only modifies its condition by permitting motion, and the consequent interference with the natural process of union. Nevertheless, this interference is so great as to occasion, in many instances, the severest form of suppuration.

Whatever form of retention be used, all circular apparatus is, in the opinion of the author, to be rejected. Immovable apparatus covering the wound was employed by Larrey, and is still, from time to time, strongly advocated by some surgeons. But whether admissible or not in the first stages of the treatment of simple fracture, it undoubtedly has great disadvantages in compound cases. The discharges accumulate beneath it, soaking the dressings, diffusing themselves over the limbs, and in some instances burrowing largely among the muscles. Such an apparatus would of course be incompatible with the success of the antiseptic treatment recommended above.

Complications.—A fracture in a healthy subject, whether simple or compound, unaccompanied by inflammation or fever, demands little or no constitutional treatment. Even the slight antiphlogistic regimen usually enforced after an accident should be modified, in consideration of the great labor of repair which is to follow. In fractures of the lower extremities aperients must be avoided, on account of the movements which they necessitate.

Complications are either local or general. The former includes affections of the skin—pruritus, vesications, excoriations, wounds, and erysipelas; of the vessels—ecchymosis and hemorrhage; of the areolar tissue—inflammation, suppuration, and gangrene; of the bone—inflammation, caries, and necrosis; of the muscular and nervous tissues—spasms, convulsions, paralysis, and neuralgia; and, lastly, of neighboring organs, the joints or viscera.

These complications may be produced simultaneously with the fracture, or may arise at a later period. Of course, for many the treatment is not influenced by the coexistence of the fracture. Pruritus is almost always the result of improper dressings. If the skin is much distended, especially when the fracture is superficial, as in the leg, there commonly arise, in a few hours, several vesications filled with a light-colored viscid fluid. If let alone they either burst or shrink from absorption of their contents. Much relief to the sensation of tension is afforded by pricking them, without removing the cuticle. They must not be confounded with the vesications of erysipelas, which are numerous and clustered, small, tense, and surrounded by the peculiar blush of that disease; nor with those which precede mortification, whose contents are dark and tawny.

Fracture of the bones inclosing a visceral cavity is not necessarily accompanied by any injury to the viscera themselves. When it is, the latter is to be treated as the primary injury, influenced by the fracture in two ways: by the movements of the fragments, or by the pressure or irritation of displaced bone, or of a splinter.

The same considerations apply to fracture extending into a joint. As this accident must, in most instances, lead to anchylosis, the joint should be placed, from an early period, in the best permanent position.

When a fracture is accompanied by dislocation, the attempt to reduce the latter must be made at the outset. The possibility of its reduction depends partly upon the kind of joint affected, and the nature of the dislocation, but principally upon the situation of the fracture. Dislocation of a ginglymoid joint may generally be reduced, especially if its ligaments are weakened by laceration. But if it be an orbicular joint, deeply buried among powerful muscles, and the fracture be below it and in its immediate neighborhood, reduction is not possible. Neither will it be possible after union of the fracture; at least, there is no instance of it on record. Nevertheless it will, of course, be right to attempt it; with which view the muscles and ligaments of the joint should be, as much as possible, relaxed by habitual movements from an early period of the treatment. Boyer also recommends for this purpose the use of emollients.

[Fortunately, these accidents are extremely rare; the reason being that when the bone is broken, there is not purchase enough upon the lesser fragment to displace the articular head, and if it is first dislocated, the force is not apt to be such as to cause fracture. Hence it is only under very exceptional circumstances that violence is so applied as to cause both luxation and fracture.]

The general complications are such as are common to all injuries, viz., inflammatory fever, hectic, delirium tremens, purulent infection, phlebitis, tetanus, and retention of urine.

In a certain proportion of cases, one or more of the above complications will necessitate either primary or secondary amputation. There are but two conditions which demand immediate amputation: profuse hemorrhage, and extensive injury to the soft parts, threatening excessive

inflammation or mortification. But the cases presenting one or other of these conditions are various :

1. When a limb is shot off by a cannon-ball or a portion of a shell.

2. When the division of the soft parts is nearly complete ; except in the case of a clean cut across the phalanges, metacarpus, or metatarsus. Even the forearm may occasionally be saved under similar circumstances.

3. When there is much actual loss of soft parts, as when one side of a limb is torn away or the skin is extensively peeled off.

4. When, in addition to great comminution of the bone, there is so much bruising and laceration, with deep separation, of the soft parts, especially of tendons, that gangrene appears inevitable. These cases, however, except as the result of gunshot wounds, are very rare. In healthy subjects, the tissues, unless absolutely destroyed, will for the most part recover. In a few cases, especially noticed by Velpeau[1] and Malgaigne,[2] the parts in the neighborhood of the fracture are within a few hours attacked by spontaneous emphysema, without any communication with the lungs. It appears to be simply an early symptom of gangrene from the sudden death of the part, and demands immediate amputation.

5. When a fracture, effected by some large body, as a wagon wheel, is accompanied by laceration of the muscles and destruction of important nerves, but not of arteries.

6. When the principal artery and nerve of the limb are both divided.

7. Some cases of hemorrhage. A wounded artery alone is not sufficient to justify the operation. But if it be accompanied by much laceration of the other tissues, the issue will depend very much on the position of the artery. If it be the brachial, the limb may generally be saved ; if the femoral, it must be sacrificed. A wound of the posterior tibial, where it is deeply covered by muscles, or of the interossei in the arm, may resist all other treatment. Amputation will occasionally be rendered necessary by general hemorrhage from a number of small branches, especially when it is persistently induced by warmth. There are, indeed, cases on record where it has been required in simple fracture of the tibia, in consequence of continued oozing from the divided medullary artery. There is a peculiar form of injury mentioned by military surgeons, ascribed by some to the wind of a cannon-ball, but by Larrey, with more probability, to a spent ball, in which, without any division of the skin, the bone, muscles, and tendons are crushed, and the artery lacerated. Before amputation, the skin should be divided and the parts examined, as it may be that the muscles are the only soft parts injured, in which case the limb may be saved.

8. Several forms of compound fracture of large joints, viz., when either bone of the joint is shattered, or both are broken ; when there is much destruction or laceration of the ligaments ; when, in addition to comminution of the bone, there is much contusion of the soft parts, especially if complicated with division of an artery ; when the articular surfaces both of the bones and ligaments have suffered much damage, accompanied by effusion into the joint ; when there is displacement of the fragments within the joint, and they present rough edges, as in the case of separation of the condyles of the femur, transversely from the shaft or perpendicularly from each other, in consequence of the passage of a ball ; when the foreign body which has caused the fracture remains in the joint, or projects into it from its bed in the bone, and cannot easily be removed, or when, in its passage through the joint, it has inflicted great injury on the articular surfaces ; and, lastly, in the case of an extensive incised wound into a large ginglymoid joint, with internal effusion of blood. It is to be understood that all these forms of injury are most fatal when affecting the knee : in dealing with other joints much greater latitude may be allowed. Moreover, whenever the injury is confined to the joint, with little or no damage to the neighboring soft parts, excision may be substituted for amputation.

But although it is true that under most of the above conditions salvation of the injured limb is well nigh hopeless, and the attempt would jeopardize the life of the patient, yet it must be admitted that the discrimination of the cases in which that attempt may reasonably be made is frequently a matter of difficulty, and has created much discussion. For, besides the extent, kind, and position of the injury, the age, constitution, and habits of the patient materially influence the result. Many limbs may be preserved in the young and healthy which must otherwise have been sacrificed. Moreover, with them greater risks may be incurred, as they are better able to encounter the dangers of secondary amputation, if it become necessary. The introduction of Lister's treatment, too, will justify the attempt to save many a limb that must formerly have been condemned.

If, in addition to the fracture, there are serious injuries to other organs, immediate amputation is either useless or

[1] Médecine Opératoire, 2d ed., t. ii., p. 321.
[2] Traité des Fractures, etc., 1847, p. 351.

injurious. In such a case the only chance of recovery is afforded by secondary amputation after the early dangers are past.

Secondary amputations may, of course, be required for profuse suppuration with hectic, for gangrene, or for uncontrollable hemorrhage. These, being common to other forms of injury, demand no special notice.

At a still later period, after all danger has ceased, the operation may be desired by the patient, if, in consequence of non-union, incurable deformity, or tedious disease of the bone, the limb has become an encumbrance to him. Similar symptoms may occasionally be treated by excision.[1]

Process of union.—Notwithstanding the labor which has been bestowed upon the study of the healing process in bone, the greatest misconception of its nature has, till within the last few years, prevailed, and many of its details remain yet to be determined. This is due to many causes: the nature of the tissue; the scarcity of opportunities for examination of the various stages of the process in man; its essential difference in animals, on which alone experiments could be made; and, lastly, actual differences in different fractures, according to their varying conditions.

The injury is seldom limited to the bone, but is accompanied by more or less bruising and laceration of the neighboring soft tissues and surrounding extravasation of blood. This extravasation varies greatly in quantity, and is unequal in its distribution. If no considerable vessel is torn, it is in proportion to the displacement and sharpness of the fragments, and the extent of injury to the periosteum. It is most abundant in the subcutaneous cellular tissue. Here, too, its absorption is least rapid; Paget having found it, in one case, nearly unchanged after a period of five weeks. In the periosteum and medullary membrane there is usually little or none. The periosteum is rarely much damaged in simple fracture. It is not often stripped off, but is generally simply torn across, and slightly frayed at the edges, but retaining firm union to the bone up to the level of the fracture. In partial fractures it is frequently uninjured. It may even remain entire in complete fractures, especially in children, in which case it subsequently thickens, contributing to the facility and security of the repair.

During the first two or three days there is a slight inflammatory exudation amongst the soft tissues. Only in the severer cases does this amount to distinct swelling, perceptible for many days, and accompanied by general fever. It is succeeded, according to Paget, by a period of rest, of incubation, lasting for a week or ten days, or even more, during which absorption of the blood and effused fibrin proceeds; but the proper reparative process is suspended. Meanwhile the deep-seated muscles, in all cases more or less lacerated, are found adhering together and to the neighboring soft tissues and periosteum, their torn ends rounded off and lost in the fibrinous effusion. About the sixth day their repair has commenced, and is completed by cellular tissue some time before the union of the bone is effected. About the end of the first month they have lost all adhesion to the periosteum.

The proper reparative process of the bone is precisely analogous to that of soft tissues. It is divisible into two parts, as distinct in their objects as in the time which they occupy, the former being completed, or nearly so, before the second begins; viz., the actual process of union, and the subsequent shaping of the fragments and of the uniting substance.

In a few cases, immediate union occurs without the intervention of any new material. According to Paget, this is very rare: but Hamilton considers it to be a frequent, if indeed it be not the normal mode of union in spongy bones, and the spongy extremities of long bones, especially after impacted fractures, as seen in the neck of the humerus and femur.

In the great majority of cases, however, a proper reparative material is provided, precisely similar in its early growth to that employed for the repair of soft tissues by adhesion. This material is of course supplied mainly by the vessels of the bone itself and of the periosteum; in a minor degree by those of the medullary membrane; and secondarily, through the intervention of the above, by the vessels of the surrounding tissues. The period of its first effusion in man cannot, as yet, be accurately stated; probably it is between the tenth and twentieth days in fractures of the large, but earlier in those of the small, bones. If the injury to the neighboring tissues be but slight, and the fragments have been, from the first, kept at rest and in strict apposition, this material is found chiefly, or it may be solely, between them. When it extends beyond them, it occupies, indifferently, the tissue of the periosteum, the space external to it, or between it and the bone; variations in this respect depending probably on the degree and nature of the injury to the periosteum itself. In Fig. 84, representing the section of a femur fractured above the condyles six weeks before, the con-

[1] Excision of the knee has been performed for mal-union of the patella. Med.-Chir. Trans., vol. xli., p. 195.

necting tissue, distinguished by a well marked transverse striation (*b*), is shown lying between the fragments, and also between them and the periosteum, which in this, as in many instances, is much thickened (*a a*). In a recent specimen the reparative material may also be traced

Fig. 84.

Fracture of the femur, to show the conditions of union six weeks after the accident. From the Museum of the Royal College of Surgeons, No. 415.

slightly into the medullary tissue, but not between it and the bone. The extent of its external diffusion may vary on different aspects of the bone. In fractures of superficial bones, as of the tibia, it not unfrequently happens that the deep surface is rough with deposits, from which the superficial is perfectly free.

The transitional forms through which this material passes in its development into bone are not in all cases the same. In a few, ossification is preceded by the production of perfect fibrous tissue. This is the case in the union of fracture of the cranium, and, perhaps, of other flat bones; in some slowly-uniting fractures of long bones; and in the closing of the exposed end of the medullary canal, when the fragments overlap. More frequently, however, the deposit of earthy matter proceeds simultaneously with the development of the fibrous matrix, so that the rudimental nucleated blastema appears to be at once developed into bone. This is stated to be the normal form of ossification in the repair of quickly-uniting fractures. Lastly, in some cases, especially in young subjects, the development is through fibro-cartilage. In animals, genuine cartilage is commonly, perhaps always, produced. Hence it has been conjectured that it may be found, occasionally at least, in children. But although the general appearance of the new tissue has been adduced in support of this conjecture, it has not as yet been proved that it is ever more in the human subject than fibro-cartilage.

Whichever of the above modes be followed, ossification may commence either at the surface of the old bone, or in several separate centres. The corpuscles, at first round, rapidly shoot out and acquire their peculiar characters. Then the Haversian canals are formed, and subsequently canals for bloodvessels. For some time the new bone is porous and spongy, like fœtal bone; its change into compact bone is very gradual.

When the fragments do not actually correspond, the uniting medium occupies externally the angle between them, and extends partly into and across the medullary canal. When they completely overlap, and even when there is an interval between them, provided it be not too great, the same rule prevails. The reparative material simply lies between them, bridging over the interval, and filling up all angles and irregularities. It does not occupy any part of the medullary canal; it does not even cover the exposed ends of the bone. This simple *gluing* together, as it were, of the adjoining surfaces, without any redundant matter, is well shown in Fig. 85 (p. 498), of a tibia sixteen weeks after fracture. (Mus. Coll. Surg., No. 438.)

When, in addition to overlapping, the fragments are more or less widely separated, bridges of new bone, greatly varying in extent and connections according to the requirements of different cases, form the bonds of union. In the femur here represented (Fig. 86, p. 498, from Mus. Coll. Surg., No. 458), where there is great divergence of the fragments, such a bridge unites the end of the lower fragment to the side of the upper. The quantity of rough deposit on the shaft of this bone is a measure of the disturbance to which it was subjected during union. In the humerus depicted in Fig. 87 (Mus. Coll. Surg., No. 2938), a strong bridge of union has been formed by the attachment of the two extremities of a large separated splinter to the respective fragments.

Under certain circumstances this process undergoes a modification so marked, that its essential identity with the process of union in other tissues was long overlooked. Of universal occurrence in animals, and therefore observed in all experiments, this modification was first fully described by Dupuytren, on whose authority mainly it was accepted, till within a few years, as the sole and normal mode of union of simple fractures. It consists in the production at an early

period, of a ring or "ferule" of bone around the fragments, called by Dupuytren "provisional callus," and constituting a kind of natural splint, beneath which the permanent union by intermediate or "definite" callus takes place much later. The whole process was conveniently, though artificially, divided by Dupuytren into five periods.

In the first, comprising in animals eight

Fig. 85. Fig. 86. Fig. 87.

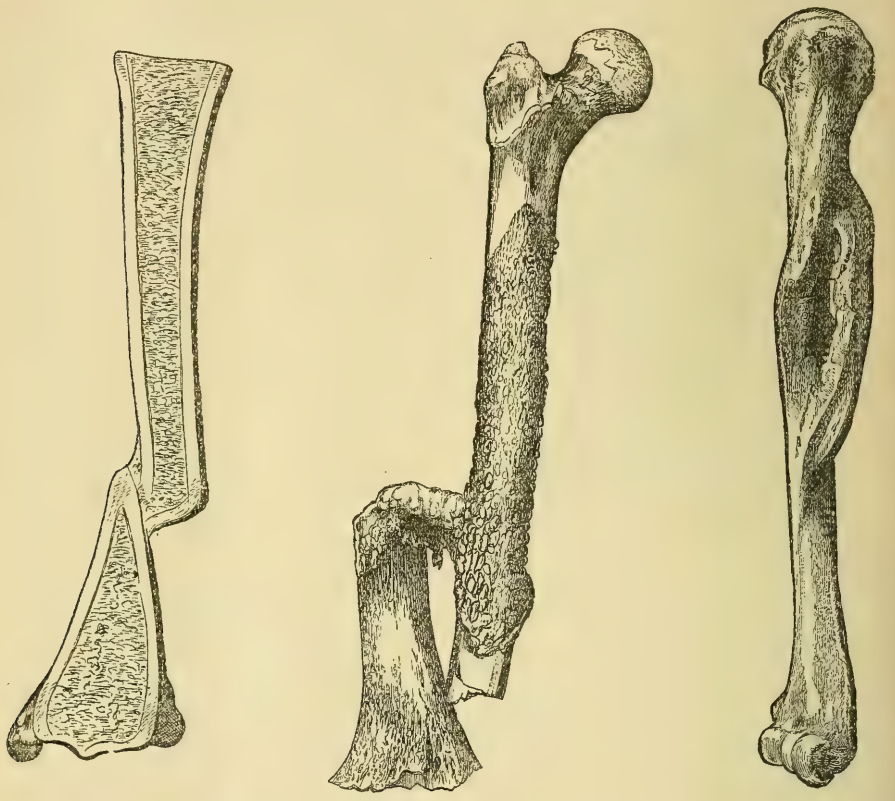


Fig. 85.—United fracture of tibia. From the Museum of the Royal College of Surgeons. To show the fragments merely glued together by reparative material thrown out between them.

Fig. 86.—Union of displaced fracture by a bridge of bone. From a preparation in the Museum of the Royal College of Surgeons.

Fig. 87.—Union of fracture by the attachment to each fragment of a bridge formed by a separated splinter. From a preparation in the Museum of the Royal College of Surgeons.

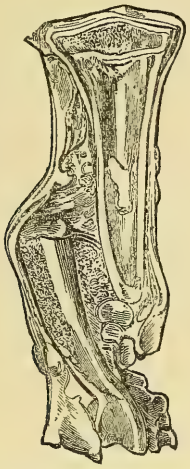
or ten days, the peculiarity of the process is already seen in the more copious exudation of the reparative material, both externally to the fragments, between them and the periosteum, and internally, but to a less extent, between the medullary membrane and the bone. The great abundance of the effusion, its position round the fragments, and the lifting of the periosteum, are all displayed in the annexed figure (88) (p. 499), of a fractured tibia in a rabbit. (Mus. Coll. Surg., 420.) So early as the fourth day this exudation contains cartilage cells, which rapidly multiply, so that by the eighth or tenth day it exhibits the structure of soft cartilage.

In the second period, from the tenth to the twenty-fifth day, while the muscles are separating from the periosteum, the soft external or provisional callus gradually acquires firmness, with the perfect structure of cartilage or fibro-cartilage. It is frequently contracted immediately opposite the fracture, and adheres closely to the surfaces of bone beneath. The same change takes place in the internal callus, or "plug," which gradually fills up and obliterates the medullary canal, being blended with the substance between the fragments.

In the next stage, both the external and internal callus ossify, ossification commencing in the parts farthest from the fracture. The period occupied by this change is variable. According to Lebert, bone-corpuscles are visible in the callus, especially near to the old bone, so

early as the tenth day, and ossification is complete by the thirty-third. Dupuytren, however, assigns it to the period between the twenty-fifth and forty-eighth,

Fig. 88.



Fracture of the tibia of a rabbit, to show the first stage of a union by provisional callus. From a preparation in the Museum of the Royal College of Surgeons.

or even the sixtieth day. The new bone at first consists of spongy tissue, but in the fourth period, from the fiftieth day to the fifth or sixth month, it is stated to become compact. In by far the majority of cases, however, this change does not take place: the callus remains spongy, or becomes compact only on its surface. How great an extent of callus may thus be converted is seen in Fig. 89, representing the ossified

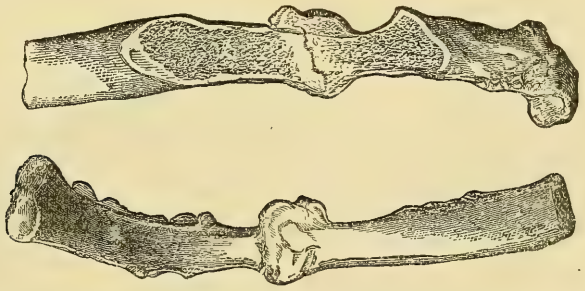
Fig. 89.

Ossification of provisional callus. Museum of the Royal College of Surgeons.

radius and ulna of a small bird, where, on the ulna at least, the callus is considerably larger than the original bone. (From Mus. Coll. Surg., No. 426.)

Lastly, about the fifth or sixth month, the intermediate tissue ossifies, forming the permanent bond of union, or permanent callus. In a very few cases, however, there appears to be an arrest of de-

Fig. 90.



Union by provisional callus in the human subject. The provisional callus has ossified; the fractured ends being still united by fibrous tissue only. From St. George's Hospital Museum.

velopment previously to this last change; so that there is never any direct union of the fragments, which remain in the condition of the human rib (three months after fracture) represented in Fig. 90 (from St. George's Hosp. Mus., I., 72), where the line of fracture is still occupied by fibrous tissue only, surrounded by a large, ossified callus. Malgaigne incorrectly represents this as a usual and normal occurrence, imagining that the permanent callus is met with only when the external has been absorbed by pressure.

The only bones which normally and constantly unite by this process in man are the ribs. Occasionally it is seen in the clavicle and humerus; rarely in the tibia, fibula, and other bones. In children, however, it is more frequent; according to Hamilton, almost constant. Although Dupuytren entertained the idea that the provisional callus was intended

as a temporary support during the early stages of union, there appears no just ground for regarding it in any other light than as the natural result of the irritation generated by the perpetual movements of fragments invested by much areolar tissue.[1] For in certain fractures, as those of the olecranon, acromion, coracoid, and cranium, it is rarely met with, only when there has been excessive irritation; and never in the fractures of parts surrounded by synovial membrane, although in them it would be of especial service for the supposed purpose. Moreover, its great extent in some instances, and its somewhat capricious distribution in such a case as that represented in Fig. 89, show that it is the result simply of irritation. The tardy ossification of the permanent intermediate tissue may arise from the mechanical obstruction of the external ring of bone.

A condition in many respects analogous to that just described is met with in the repair of certain fractures in the neighborhood of joints, especially of the hip-joint, when accompanied by much deformity, in which strengthening buttresses of bone are thrown out, on the concave side, manifestly as the result of irritation.

In inflamed simple and compound fractures a third mode of union is met with, viz., union by granulations.

In compound fractures there is usually greater injury to the soft parts than in simple. Either they are crushed and their vital powers annihilated at once, or great inflammation is followed by extensive suppuration and sloughing. The periosteum is generally torn away from the bone, and the medullary membrane is either crushed and lacerated or involved in the subsequent inflammation. The inflammatory effusion among the deep muscles generates a capsule among the fragments, arising from the healthy bone beyond the torn periosteum. In the majority of cases, the ends of the bone, thus lying in a closed abscess and bathed in pus, die, the necrosis being limited by the extent to which the periosteum and medullary membrane are torn away. After the separation of the sequestrum, granulations spring up from the exposed surfaces and ossify. If the necrosis does not involve the whole thickness of the bone, partial and imperfect union may take place before the separation. Generally the slow exfoliation and the lengthened suppuration so weaken the powers of the part and of the constitution that ossification is tedious and may be altogether arrested. Even when there is no necrosis the progress is in all other respects the same. After the completion of union the adaptation of the fragments is generally less perfect than after simple fracture; morbid deposits of bone from inflammation are more frequent and more irregular, and there is greater adhesion of the tissues one to another. This is especially observable after compound fractures of superficial bones, as the tibia, to which the skin is often long adherent.

[In 1865, M. Ranvier, from his experiments, showed that the callus in simple fractures, whether in man or in animals, passed through a cartilaginous stage; while in compound fractures it became at once developed into bone from granulations springing from the medullary substance of the fractured bone.

He further demonstrated that suppurative inflammation had no effect upon the process of ossification in the cartilaginous callus, when the latter was once formed.

M. Ranvier's experiments established a fact not previously recognized, and called for researches to explain why the bony cicatrix formed by a different process in different cases. This question MM. Rigal and Vignal set themselves to answer.

Repeating M. Ranvier's experiments, they obtained the same results. They also remarked:—

1. That, even in simple fractures, the central pin of callus always became bony directly from the medulla, the latter resuming its embryonic condition.

2. That on scraping a part of the bone, whether down to the medullary canal or less deeply, the cicatrix was always directly bony, even when there was union by first intention; a fact already recognized by M. Ranvier.

3. That in a compound fracture, even when the fragments of the bone were left exposed to the air for a somewhat long time, if suppurative inflammation was avoided—if, that is to say, union took place by first intention—the callus passed through a cartilaginous period.

4. That in a compound fracture with suppuration, the callus was at first cartilaginous at points not the seats of suppuration, while in simple fractures, the fragments of which, however, were from any cause bathed in pus, the callus was from the first bony.

These various facts led MM. R. and V. to the opinion that the periosteum, or more exactly the subperiosteal areolar layer, was destroyed by the very process of suppuration; they concluded that it was to this layer only that the formation of cartilage should be ascribed, and that from the medulla of the Haversian canals,

[1] Paget suggests a second reason for its constancy in animals—a greater general tendency in them to the production of bone. Lectures on Surg. Path., vol. i., p. 240.

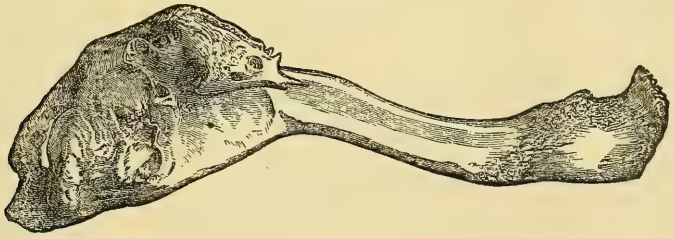
as well as from that of the central cavity, bone was directly formed.[1]]

The changes which occur in the latter part of the process of repair, viz., the shaping or modelling of the bone after its union is complete, so as to restore it as nearly as possible to its original condition, are these: 1. All rude and unnecessary projections are removed by absorption. The sharp points left by the overlapping of ill-united fractures, whether deep or superficial, are first softened by the disappearance of their earthy matter, and subsequently removed and rounded off. It has been questioned whether, after the repair by provisional callus, this callus, once ossified, is absorbed. The absorption is certainly not complete. In most ribs that have been broken there remains more or less enlargement at the seat of fracture. M. Lambron refers all absorption to the continual pressure and friction of the muscles.[2] 2. When the fragments overlap, the exposed ends of the medullary canal are closed by a layer of compact tissue (Fig. 85). 3. The new bone, at first uniform in structure, has to acquire the firmness and strength of compact bone externally, and internally to be hollowed for a new medullary canal. Whatever the relative position of the fragments, the medullary canal usually becomes continuous in the two. Even where they overlap, their compact walls are absorbed, and the cancellous tissue and canal of the one become eventually continuous with those of the other. In the clavicle here represented (Fig. 91, from St. George's Hosp. Mus., I., 87, and I., 88) the restoration of the cancellous tissue is almost perfect, notwithstanding the irritation to which the part must have been subjected during union, as evidenced by the large irregular deposit of new bone externally (Fig. 92). It sometimes happens, however, that the plug which is

Fig. 91.

Section of fracture of the clavicle, united with much external deposit of bone—showing the restoration of the cancellous tissue of the bone. From St. George's Hospital Museum.

Fig. 92.



External view of the same preparation.

formed in the process of union by provisional callus remains as a permanent septum. For a long time after union the new bone is more vascular than the old, and contains more animal matter.[3] Generally, in the course of a year or more, all the tissues concerned are restored to their normal state, however much their relative positions may be altered.

If the coaptation of the fragments is good and union healthy, the old bone itself undergoes no change. Curling, indeed, has endeavored to show that, in fractures of long bones, the fragment which is cut off from the nutrient artery becomes more or less atrophied;[1] but his theory has received no support from other

[1] [Acad. des Sciences, Gaz. Méd. de Paris, June 12, 1880.]

[2] Thèse Inaug., Paris, 1842.

[3] Von Bibra, in Chem. Unters. über die Knochen, etc., 1844, p. 305; and Howship, Med.-Chir. Trans., vol. ix., p. 143.

[1] Med.-Chir. Trans., vol. xx., p. 336.

observers. But if there is great overlapping with tedious union, both fragments suffer more or less atrophy; they are shrunken and conical, and their cells enlarged. The same condition may result from other causes of local debility or tedious union.

The time requisite for the various stages or for the completion of union can never be predicated with certainty. No deductions from experiments on animals can be applied to man. Only approximate dates can be given. Ossification, in the ordinary mode, in simple fractures, is rarely completed before the ninth or tenth week, even under favorable conditions. This period is subject to variation from many causes; the age of the patient, the size and situation of the broken bone, the nature of the fracture, and the relative position of the fragments.

In infants fractures unite with marvellous rapidity. Ten or twelve days are often sufficient for the forearm or humerus. On the other hand, in old age the period is greatly protracted, in proportion to the want of vigor of the individual. *Cæteris paribus*, the larger a bone, the longer a period it requires for its union. It may be on this account alone that the bones of the lower extremity appear to unite more slowly than those of the upper. But, however this be, the position of the former, throwing upon them much more violence and weight, prolongs the period necessary for the treatment of their fractures, which ordinarily require the retention of apparatus from eight to twelve weeks, while three or four suffice for those of the upper extremity.

The relative position of the surfaces of the fragments has the most marked influence over the rapidity of union. If they overlap, it is proportionately retarded. If, in addition to overlapping, they are more or less separated; or if they are very oblique and smooth, so that they readily glide one over the other; or if they touch only by their periosteal sides, nearly double the ordinary time will be required for their union, partly, no doubt, in consequence of the difficulty of maintaining them at rest. Cases of double fracture, in which it is difficult or impossible to prevent riding, are always tedious.

Compound fractures demand, on an average, three times the period required for simple. The most tedious are gunshot wounds, on account of the extensive comminution of the bone, and the damage to the soft parts. Next to them are clean-cut fractures, in which nearly all the tissues are divided.

When there has been actual loss of bone, in consequence either of the removal of splinters or comminuted portions, or of sawing off the end of one of the fragments, the extent of restoration varies in different cases. In most instances it is little or none, and the limb is permanently shortened to the extent of the loss. Many remarkable cases, however, are recorded of the regeneration of large pieces of bone, generally in the tibia. Delamotte mentions one in which no less than six inches of the bone were restored.[1] In another related by Gooch,[2] five inches; and in others, two, three, four or five[3] inches have been replaced. The more favorable cases of this kind occur in young subjects, and the restoration is effected by the ossification of effused lymph. The more it is by granulation the less perfect is it. From the recent experiments of M. Ollier,[4] confirmed, as they have been, by others, it appears that the restoration is exactly in proportion to the integrity of the periosteum, the preservation of which membrane is therefore of the first importance in all cases of resection.

Perforations of bone by balls, or other foreign bodies, generally become filled, more or less, with new bone. When the perforation is large, bony offshoots from the edges partially, but never completely, close it.

A fracture extending into a joint is never followed by reunion of the articular cartilage. There is always on the second or third day, or even earlier, more or less synovial inflammation. In simple fracture this may subside without further mischief; the bone unites, leaving an interval between the borders of the cartilage, which may or may not be filled with fibrous tissue. In more severe cases a false membrane may form on the synovial surfaces; or inflammation extends to the cartilage, which is more or less eroded, and a cure is effected by fibrous, or, rarely, by bony, anchylosis. In compound fractures some degree of destruction and subsequent anchylosis is inevitable, in proportion to the size of the joint and the nature of the fracture. Rarely, indeed, does a fractured joint entirely recover its functions.

Separations of epiphyses unite by the same process as fractures. But if the union is vicious, and the separated epiphysis is the head of the humerus or femur, this accident is invariably followed by atrophy of the limb, from imperfect

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[1] Traité Comp. de Chirurgie, obs. 80.

[2] Cases and Practical Remarks in Surgery, 1758, p. 97.

[3] Recorded by Phillips, Van Swieten, and Dunn. See Obs. on Compound Fractures, in Med.-Chir. Trans., vol. xii.

[4] Recherches Exp., etc., in Brown-Séquard's Journ. de la Phys., Jan. and April, 1859.

growth of the injured bone; the consequence, apparently, of the partial destruction of the fibrous layer connecting the epiphysis to the shaft (*v.* also p. 482).

Ununited fractures. — The process of union may be delayed or completely arrested at any period of its progress. But, inasmuch as the time requisite for consolidation is very variable, and there are no signs by which to determine the precise period of arrest, the distinction between retarded union and non-union is more or less arbitrary. They both acknowledge the same causes, and demand similar treatment.

Certain fractures, from special causes, rarely unite by bone. They are, intracapsular fracture of the neck of the femur, of the condyles of the humerus, of the olecranon, coronoid process, and the patella.

Ununited fractures are, fortunately, rare. Amesbury,[1] indeed, states that he had in 1828 seen fifty-six cases, and some years later ninety; but his experience is quite exceptional. Lonsdale[2] found that of 4000 fractures treated at Middlesex Hospital, only four or five refused to unite; Norris[3] did not meet with one case out of 946 fractures: the cases which he saw were sent from elsewhere. Liston met with only one in his own practice; and other surgeons give similar testimony. Hamilton reckons that they do not exceed one in 500 cases, and even this estimate appears high. They are more frequent in males than in females. The relative liability of different bones is exhibited in a table of 150 recorded cases drawn up by Norris. Of these, forty-eight occurred in the femur, forty-eight in the humerus, thirty-three in the leg, nineteen in the forearm, and two in the lower jaw. Other bones, however, are not exempt; instances having been met with in the clavicle, ribs, acromion, and even the spine.

[In the excellent article on Fractures in Agnew's Surgery, vol. i., p. 752 *et seq.*, will be found tables embracing 685 cases of non-union, with valuable details.]

The mode of connection of the fragments is of four kinds: 1. In a few cases, they are enclosed in a mass of fibro-cartilage. This may be provisional callus arrested in its development, or the result of subsequent irritation. This variety of union is always painful under rough handling. 2. In others, also, but few in number, and only in anæmic subjects, there is absolute want of uniting medium of any kind. The ends of the bone are atrophied, loose, and very movable. The limb is shortened, and quite powerless. 3. Occasionally a genuine diarthrodial joint is established. A typical illustration of such a joint in the humerus is shown in Fig. 93. (Mus. Coll. Surg., No. 462.) The ends of the fragments are greatly enlarged, each being alternately concave and convex, and fitting accurately to the irregularities of the other. These ends are covered by a smooth fibrous tissue, the whole being surrounded by a strong capsular ligament, represented in the drawing only at the sides. In other cases the ends of the bone are covered with cartilage, or worn down by friction to a hard, or even ivory-like surface. In the preparation in the Museum of the College of Surgeons (No. 469), from which Fig. 94 is taken, and which is described as a fracture of four or five years' standing, the ends of the bone are, as here depicted, studded with cartilage, and enclosed in a large and loose synovial capsule, in which were found a great number of false cartilages. This kind of union is always the result of considerable motion. It is never seen after a compound fracture, when there is always some kind of fibrous connection. 4. In by far the majority of cases, the union is by fibrous tissue. This tissue adheres firmly to the bone, and is very pliable. In some cases it is so short as to constitute a kind of synchondrosis between the fragments, admitting of scarcely any movement. In others it is long and flexible. It may be entire, or separated into two or more bands. The ends of the bone are commonly smooth and rounded off; sometimes they are shrunken and pointed; at others more or less enlarged by accessory bony growths —a circumstance highly favorable to the prognosis. The medullary canal is closed.

It is not always possible to ascertain the actual condition of the part; but the points to be observed, as bearing practically on the treatment, are, the relative positions of the fragments; their mobility; as far as possible, their condition; the degree and nature of the deformity; and the sensitiveness of the part under manipulation.

The causes of non-union are constitutional or local. The former include all those conditions in which the powers of the system are much impaired. They are old age, pregnancy, lactation, syphilis, phthisis, fevers, general cachexia, and scurvy.

General fevers and internal inflammation always arrest the progress of union, and may even cause resoftening after its

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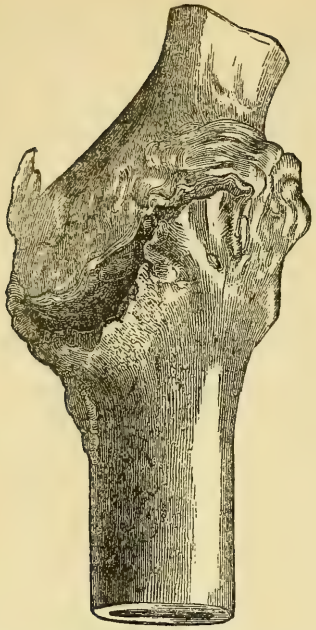
[1] Obs. on Nature and Treatment of Fractures, etc., pt. ii., p. 193, Lond., 1828.

[2] Practical Treatise on Fractures, London, 1838.

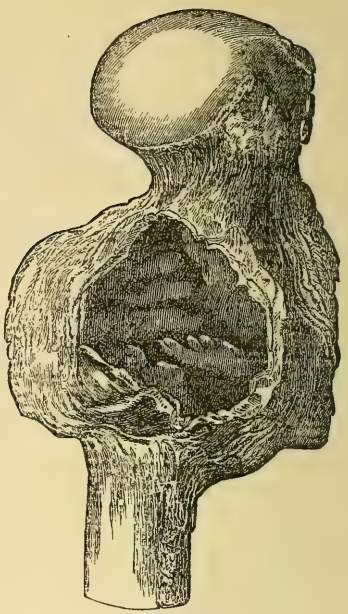
[3] "On the Occurrence of Non-union after Fractures," Amer. Journ. of Med. Sci., Jan., 1842, art. 1: the most complete article for reference on the subject.

Fig. 93.



False joint after fracture; showing the ends adapted to each other, and united by a capsular ligament. From the Museum of the Royal College of Surgeons.

Fig. 94.



False joint after fracture; showing a large and loose synovial capsule containing numerous false cartilages. From the Museum of the Royal College of Surgeons.

commencement. It is only when accompanied by unusual debility, as in some cases mentioned by Bonn,[1] that old age is able to retard it. The same is true of pregnancy, lactation, and syphilis, the influence of which has been doubted by some authors.[2] Schmucker saw union delayed, in unhealthy or scrofulous subjects, for eight or nine months, and in one case for more than a year.[3] Insufficient food, or the want of an habitual stimulus, will prevent union.[4] Brodie refers to the examples of two corpulent patients, one male, the other female, in whom an intentional persistence in low diet for some months previous to the fracture had this result.[5] In consequence of bad and insufficient food, almost all the gun-shot wounds which Larrey witnessed in Syria were followed by non-union.[6] It has been traced to the enervation consequent on habitual discharges,[7] to general dropsy,[8] to copious bleeding, followed by low diet.[1] Heath, of Newcastle, has noticed that the diet of most of his patients has been deficient in vegetable aliments.[2] But the most marked effects of impaired nutrition are witnessed in scurvy; the power of which not merely to prevent union, but to dissolve it months, or even years, after its completion, has been pointed out by Lord Anson,[3] Sir S. Hammick, and Desault.[4]

In certain obscure cases, in the absence of apparent cause, non-union has been ascribed to some unknown peculiarity of constitution. Two such cases are recorded by S. Cooper,[5] and five by Sanson.[5] A clue may, perhaps, be given to at least some of them by an observation made by Penel.[7] He found the urine of his patient alkaline, and loaded with earthy phosphates. In a few cases of tardy union the author has found these phosphates in excess, but not always with alkaline urine. This condition appears to be due to long confinement.

[1] Art. "Fracture," in Dict. de Méd., 1836, t. xiii., p. 402.

[2] For examples of non-union from these causes, see Norris's paper, supra cit.

[3] Vermischte chir. Schriften, B. i., p. 26.

[4] "Cases of Ununited Fracture," by B. Page, Med.-Chir. Trans., 1848, p. 135.

[5] Med. Gaz., vol. xiii., p. 53, vol. xiv., p 616.

[6] Mém. de Chir. mil., 1812, t. ii., p. 131.

[7] Marrigues, Diss. sur la Form. du Cal, Paris, 1783; and Thierry, L'Expérience, 1841.

[8] A. Cooper, sup. cit., p. 570.

[1] Hewson, Jour. du Progrès, t. ix., p. 161.

[2] Lancet, 1855, vol. i., p. 611.

[3] Voyage round the World, 15th. ed., p. 142.

[4] Journ. de Chir., t. ii., p. 318.

[5] Dict. of Prac. Surg., 7th ed., 1838, p. 551.

[6] Dict. de Méd. et de Chir. prat., t. iii., art. "Articulation Anormale."

[7] Lond. Med. and Phys. Jour., vol. xiv., 1805, p. 29.

The local causes are much more numerous. They are either indirect, as inflammation of the soft parts, paralysis, obstructions to the circulation, and local anæmia from bad treatment; or direct, viz., diseases of the bone, the presence of a foreign body, separation of the fragments, and motion.

Local inflammation, or abscess, or an ulcer, usually retards union. Wardrop[1] mentions the case of a sailor with compound fracture of the leg, in whom, on three separate occasions, the uniting medium was re-softened in consequence of attacks of erysipelas. A few instances of non-union from recent paralysis have been met with.[2] The result, however, is not constant, at least in paralysis of long standing; for a fractured tibia has been known to unite readily in a man who had been palsied for twenty years.[3]

Obstruction to the circulation by pressure upon,[4] or ligature of, the main artery above a fracture occasions considerable delay of union. This was shown by Brodie in numerous experiments on animals.[5] The same is the result of early, tight, or prolonged bandaging. In France, where the treatment by immovable apparatus has been employed much more extensively than in England, it has been found that fractures so treated unite in general but slowly, occasionally not at all;[6] and Troja and Duhamel proved experimentally the prejudicial influence of strong pressure over the seat of fracture. Prolonged bandaging, or the excessive employment of emollients and refrigerant lotions in the early treatment, produces an anæmic condition of the limb, to which Cloquet[7] has given the name of local scurvy. The skin is pale, and deprived of its natural secretion; the cuticle separates; the whole limb is shrunken or œdematous. Sometimes points of ecchymosis appear, which extend more or less over the limb. In compound fractures the granulations become soft and livid, readily bleeding, and secreting a thin, ichorous pus. Of course, consolidation of the fracture is arrested.

Separation of fragments is manifestly the cause of non-union in fracture of the patella, and probably in all those special fractures which rarely unite by bone. It is, perhaps, the real obstacle to union in those few cases in which a fragment of muscle or tendon,[1] or a large effusion of blood, has been found interposed between the fragments; as, were the interval small, pressure could scarcely fail to cause absorption of the intervening soft tissue. In one singular instance, mentioned by Berard, a fractured clavicle united by two bridges of bone, inclosing the ossified subclavius.

The most constant cause of non-union is undoubtedly motion. Norris was able to trace this cause for twenty-two out of forty-four cases, and suspected it in others. Amesbury goes much farther. He maintains that it is the cause in almost all cases, and that it is due generally to the inadequacy of the ordinary apparatus. That this is an exaggeration is shown by the facility with which most fractures unite under ordinary, or even bad treatment; by the rarity of non-union in the ribs and clavicles, or after double or compound fractures; and by the occasional reabsorption of the callus from fevers. To prevent union, the motion must be considerable and long continued. To the influence of certain powerful muscles, as the deltoid and psoas, is due the frequency of non-union in the humerus and femur.

Numerous measures have been devised for the cure of pseudarthroses. But, as the distinction between the delay and arrest of the process of union is in all cases doubtful, it is only after the failure of the milder methods that recourse to operation is justifiable. For practical purposes, indeed, the failure of all means short of operation may be regarded as the only absolute proof of such arrest.

The indications for treatment are four. 1. To remove all local impediments, as foreign bodies, dead bone, and disease of the bone or soft parts. 2. To improve the general health. 3. To insure the primary conditions of union, immobility and contact of the fragments. 4. To excite, by artificial means, the suspended reparative action between and around the fragments.

The various constitutional cachexiæ must of course be met by their own special remedies. Change of air and scene, and improved living, are often all-sufficient treatment. In cases of debility, with excessive secretion of phosphates, as in Penel's case, mineral acids and tonics are required. Mercury, given to salivation, as first recommended by Fleury, even in cases where there is no suspicion of syphilis, has been much vaunted by

[1] Med.-Chir. Trans., vol. v., p. 378.

[2] Travers's Further Inquiry, etc., p. 436; and B. Phillips, in Lond. Med. Gaz., May, 1840.

[3] Busk, Lond. Med. Gaz., 1840, p. 97.

[4] Davies, in Lancet, Feb. 5, 1859.

[5] Med. Gaz., vol. xiv., sup. cit.

[6] Réponse à M. Rognetta, etc., Gaz. méd., 1831, p. 630.

[7] Art. "Fracture," in Dict. de Méd. sup. cit.

[1] S. Cooper, in Dict. of Pract. Surg., 1838, p. 551; and Stanley, in Lancet for 1854, vol. i.

some, and has occasionally been of service where other means have failed.[1] It has, however, repeatedly been found useless, and can be tried with safety only on plethoric patients.

The local means which have been adopted to answer the remaining indications are: 1. Rest and pressure. 2. External stimulants. 3. Friction. 4. Setons. 5. Acupuncture. 6. Galvanism. 7. Subcutaneous incision. 8. Perforation of the bone. 9. Resection, with or without ligature of the fragments. 10. Resection, with preservation of the periosteum. 11. Rasping the ends of the bone. 12. Cauterization. 13. Stimulant injections. 14. Dieffenbach's operation.

Amesbury, following out his own doctrine, maintains that, except in the rare cases of preternatural joint, or when union is prevented by the presence of a foreign body or diseased bone, rest and pressure are almost invariably sufficient for the cure. By this method he has succeeded with fractures of from ten weeks' to sixteen months' standing, even after setons and other measures had failed. Although others have not found this treatment so universally successful, it must of course, in the great majority of cases, take precedence of any other. It is specially applicable in those cases where non-union depends on motion or malposition, or on deficient local action from general anæmia, without atrophy of the fragments, and in all cases attended with thickening and tenderness at the seat of fracture.

If the limb be healthy, Amesbury's or some other form of immovable apparatus is the most efficacious. But if it be œdematous, or inflamed, or atrophied, movable splints are better. There are cases, especially in children, in which it is scarcely possible to obtain perfect immobility except by including in the apparatus the adjoining part of the trunk. Lateral pressure may be made by bandages and compresses; longitudinal by crutched splints in the upper extremity, by straps and collars in the lower.[2]

In most cases it is not enough to keep the fragments in close contact. A certain amount of stimulus is requisite. For this purpose, Amesbury directs that the pressure be sufficiently great to produce pain in the course of a few days. The duration of treatment in his case varied from three to ten weeks. In others, where rest alone has been relied on, four or five months have sometimes been found necessary.[1]

The efficacy of all local measures appears to depend, not so much on the irritation of the bone itself, as on the action which they arouse in the soft parts surrounding and connecting the fragments. It has happened, in cases of tardy union, that an accidental bruise[2] or attack of erysipelas[3] has hastened the process. It is on this principle that external applications are recommended. Stimulant lotions,[4] blisters,[5] iodine,[6] galvanism, issues, and cautery, have all been used with occasional success. If the limb is atrophied, and in the condition of local scurvy, exposure to air and light, friction, stimulant embrocations, and galvanism are of the greatest service. Under other circumstances, the advantages of any of these external applications are confined to cases of simple tardy union in superficial bones. In these they are of undoubted benefit, but only when used at an early period, within eight or ten weeks after the fracture. The most tested, and probably the most efficacious, are blisters. Walker employed a succession of small ones; Velpeau, with equal success, or nearly so, a few large ones. Malgaigne suggests the substitution of sinapisms as being more rapid, but does not appear to have put his suggestion to the proof. Birch[7] found galvanism of service in two cases. Mott[8] tried it without benefit. Twice, too, a caustic-potash issue was employed with success by Hartshorne.[9]

Friction of the fragments is somewhat more stimulating than mere pressure. There are two modes of effecting it. The usual method is manual; rubbing the fragments against one another for some minutes, till a degree of uneasiness or even pain is produced. It may be repeated, if necessary, daily, till the part becomes tender and painful. It is intended to break down the connecting

[1] Hammick, op. cit.; and B. Cooper, in Guy's Hosp. Reports, 1837, p. 399.

[2] See Amesbury's Treatise for detailed description of his apparatus, as applied to different limbs.

[1] Bonnet, Gaz. méd., Sept., 1839.

[2] Wardrop, Med.-Chir. Trans., vol. v., sup. cit.

[3] Seerig, De Pseudarthrosi de fracturâ proficiscente, 1838.

[4] Cloquet, in art. sup. cit., and Jobert. See Fleury's Memoir, "Quelques considérations sur les causes qui peuvent retarder," etc., Archives de Médecine, août 1837.

[5] Walker, Lond. Med. and Phys. Journ., xxxii., p. 470; Brodie, sup. cit.; and Velpeau, Méd. opératoire.

[6] Buchanan, Essay on a new Mode of Treatment for Diseased Joints and the Non-union of Fractures, London, 1828; also Crosse and Blackwell, see Norris.

[7] In Steevens's translation of Boyer's work.

[8] Med. and Surg. Reg., part ii., p. 375.

[9] Philad. Med. Recorder, April, 1826.

bands, and even roughen the surfaces of bone. The other method, applicable only to the lower extremity, recommended first by White,[1] and afterwards adopted by Hunter, Champion, and many others,[2] is to envelop the limb in a firm apparatus, and direct the patient to walk on it. In White's case, a large abscess formed in the thigh; this, however, did not prevent a favorable result, and is the only instance in which positive harm has resulted from the treatment. In another case the apparatus could not be borne.[3] Friction should always be tried, as supplementary to rest and pressure, before stronger measures are adopted. Its greatest triumphs are in cases of general anæmia, when from the first, there has been little or no action, and the fragments are loose and movable, as in a scrofulous lad under the care of Sir S. Hammick. It is of course contra-indicated by the presence of inflammation.

Dr. Physick[4] was the first to attempt the cure of non-union by passing a seton between the fragments; though the first idea of it has been ascribed to Winslow. Since that time setons have been extensively employed, with a considerable share of success. Of the 150 cases tabulated by Norris, they were tried at some period of the treatment in seventy-two, in only twenty-eight of which they failed. Although Dr. Physick, according to his nephew's report,[5] generally succeeded by this plan in the upper extremity, and failed in the lower, subsequent experience has shown that it is specially adapted to fractures of the leg and forearm, and smaller bones. In these, failure is rare, Norris's table pointing to only one out of twenty-two cases; whereas in the humerus and femur, the unsuccessful cases slightly preponderate. The duration of the treatment has varied greatly. Physick allowed the seton to remain four or five months, or even more; in fact, till union was either completed or hopeless. Earle left it for seven weeks;[6] Wardrop recommends two or three weeks; and Liston eight or ten days.[7] No arbitrary time can be fixed; but the object being to excite local action, and not to exhaust the powers by prolonged suppuration, which, indeed, is more likely (as in compound fractures) to retard than to promote union, besides increasing the risk of erysipelas, the seton should be removed as soon as there is considerable solidification in the neighborhood. If there is no suppuration, so much the better. Adams mentions a case in which the seton was left in only four days, and was yet successful.[1] Its prolonged use does, indeed, appear to have impeded union in some instances, especially in the large bones.[2] Liston records a case where it was left in the humerus for thirteen months;[3] a useless arm was the result.

It appears from the statistics to be a matter of perfect indifference whether the bone is reached by previous incision or not. It is simply a question of convenience. Weinhold recommended a wedge-shaped seton, as being, in his opinion, both safer and more efficacious.[4] Its effect may also be increased by smearing it with red precipitate or other irritant,[5] or by combining its use with that of friction, or even with some more serious operation.

The treatment by seton is not altogether free from risk. Twice it has been fatal. Many cases have been endangered by attacks of erysipelas or profuse suppuration. In Wardrop's case[6] there was severe hemorrhage from a wounded artery. In another, under Stansfield,[7] the seton gave rise to intense pain. Its use is precluded by great separation or excessive mal-position of the fragments, by the absence of uniting medium between them, by irregular deposits of bone, by the proximity of a joint, or by the antiquity of the fracture. In most other cases, especially in the leg or forearm, it is admissible.

In two cases in the humerus, and one in the forearm, in which he was unable to introduce a seton between the fragments, Oppenheim[8] passed two, one on either side, so as to create irritation in their immediate neighborhood. He recommends the operation as more effectual than the ordinary mode, and Malgaigne considers it more rational. It is, at any rate, equally successful.

Analogous to setons are ligatures, passed round the tissue connecting the fragments, and gradually tightened till they completely cut through it, thus stimulating successively different portions.

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[1] Cases in Surgery, 1770, p. 75.
[2] Velpeau, Méd. opér., 2d ed., t. ii., p. 583.
[3] Sue, in Desault's Clinique, t. ii., p. 312.
[4] New York Med. Repository, vol. i., 1804.
[5] Brodie, loc. cit.
[6] Med.-Chir. Trans., vol. xii., 1823, p. 190.
[7] Practical Surgery, 4th ed., 1846, p. 99.

[1] Med. Times and Gaz., 1851, vol. ii., p. 391.
[2] Malgaigne, p. 311, sup. cit.
[3] Supra cit., p. 100.
[4] Hufeland's Journal, May, 1826.
[5] Weinhold, ut supra; and Liston, in Lancet, April 30, 1836.
[6] Supra cit.
[7] Mentioned by Brodie.
[8] Ueber die Behandlungsweisen der Pseudarthrosen, etc., in Hamb. Zeitschrift, vol. v., pt. 1.

Sommé[1] used a silver wire for the purpose, and Seerig[2] a waxed thread.

In one case, in the lower fourth of the femur, Malgaigne[3] endeavored to pass acupuncture needles between the fragments; but they were so close that, although he thrust in thirty-six directions, he was not able to introduce even one needle. Wiesel[4] was more successful in the forearm. He operated first on the ulna, and afterwards on the radius. The needles completely traversed the false joint, and were left in for six days, till they caused pain and swelling. The cure was complete in six weeks.

By means of needles a current of galvanism has been passed through the connecting ligament by Brennan[5] and Lente[6] of New York. Both these authors considered it of service. It was tried by Square[7] without effect.

C. Bell[8] proposed to wound and irritate the ends of the bone by the subcutaneous introduction of a pointed instrument; but he had no opportunity of carrying out his idea. More recently, M. Blandin,[9] having divided the connecting tissue with a tendon-knife, scraped the fragments with its sharp edge; but erysipelas and abscess were the sole results. A great improvement in this operation was effected by Miller,[10] who confines himself to the laceration and irritation of the connecting tissue, by passing through it, in various directions, a double-edged bistoury or tendon-knife. Brainard[11] employs for this purpose an awl-shaped perforator; and in cases of overlapping he perforates the fragments themselves in two or three places, making, however, only one small wound in the skin. The treatment has met with great success, and is applicable to most cases, but especially where the connecting tissue is long and loose. Miller suggests that it might be advantageously combined with galvanism.

Resection, scraping, and cauterization aim at more than the preceding operations. Their object, besides irritation, is to remove the effete and indolent tissue covering the ends of the fragments, and to place them in the condition of a recent compound fracture.

[1] Med.-Chir. Trans., vol. xvi., part 1, 1830, p. 36.
[2] Arch. Gén. de Méd., Jan., 1839, p. 105.
[3] Traité des Frac., 1847, p. 307.
[4] Journ. de Chirurgie, 1844, p. 85.
[5] Monthly Journ. Med. Sci., Feb., 1848.
[6] New York Journ. Med., Nov., 1850.
[7] Med. Times, 1851, vol. ii., p. 300.
[8] Oper. Surg., 2d ed., 1814, vol. ii., p. 376.
[9] Gaz. des Hôpitaux, 1844, pp. 557, 569.
[10] Miller's Principles of Surgery, 2d ed., 1850.
[11] Trans. Amer. Med. Assoc., vol. vii., 1854; and in Hamilton on Fractures, 1860 [1880].

Resection of the fragments was first put in practice by White.[1] He operated with success on the humerus and tibia. In the latter case, in consequence of the difficulty and danger of reaching the lower fragment, he excised the end of the upper one alone, irritating the other by scraping the periosteum, and destroying the soft tissue which prevented their approximation by butter of antimony. This difficulty is one of frequent occurrence in the performance of this operation; and Dupuytren,[2] on the strength of two successful cases, suggested that all the efficacy of the operation may be obtained by the resection of one fragment, and rasping the other. For many years resection was regarded with much favor. Of Norris's 150 cases, it was performed, on one or both fragments in no less than sixty-four; in thirty-seven successfully. In the leg it never failed; rarely in the forearm. But with the humerus and femur the results were far otherwise. Of twenty-seven operations on the humerus, eleven only were followed by union, two were fatal. Of seventeen on the femur, ten were successful, but four fatal. On these bones, indeed, the operation is encompassed with difficulties and dangers. In one case it lasted two hours;[3] in another,[4] after an hour's duration, it was immediately followed by fatal convulsions. Rowlands[5] was so struck with the difficulties he had to encounter in the thigh, that he admits he should hesitate to recommend it. In fact, for the larger bones its dangers are so conspicuous, that it is now universally abandoned. But in others, especially the superficial bones, it is still occasionally adopted. Where there is a true diarthrodial joint, especially if the ends of the fragments are enlarged, or rough with deposit, it is the best, perhaps the only admissible, operation. Next to these, it is most applicable to cases of long standing, or in which the fragments are loose and widely separated, or greatly overlapping. It is absolutely precluded by the neighborhood of a joint.

In some instances there has been great difficulty in keeping the fragments in contact or at rest after the operation. Three methods have been devised for the purpose. 1. M. Roux[6] locked the point of one fragment into the medullary canal of

[1] Cases in Surgery, with Remarks, Lond., 1770.
[2] "Resection de la Mâchoire inf.," Leç. Orales, t. iv., p. 658.
[3] Kirkbride, Amer. Journ. Med. Sci., xvii., p. 46.
[4] Vallet, Thèse inaug., Strasb., 1817; and in Velpeau's Méd. opérat., t. ii.
[5] Med.-Chir. Trans., vol. ii., 1813.
[6] Mentioned by Berard in art. "Fracture," sup. cit.

the other; the operation failed in consequence of a fall. 2. The fragments have been cut obliquely, so as to present a larger surface for mutual contact and support, and to admit of lateral pressure. This mode of section produces less shortening than the transverse.[1] 3. The third method is suture, either by waxed thread, used unsuccessfully by Flaubert; or, better, by silver-wire, which was first employed by Horeau,[2] afterwards, with success, by Rogers, Mott, Laugier and others, on the humerus, femur, and radius.[3] This practice, though denounced by Norris, who states that he has known an instance in which it was fatal, appears to increase the efficacy, but not the danger, of resection. In an operation on the lower jaw, in which this mode of retention is essential, Dupuytren passed the connecting wire round the teeth.[4]

Jordan ascribes the failure of resection to the removal of the periosteum. He, therefore, by means of some blunt instrument, as the handle of a scalpel, dissects this membrane from the portions of bone which he is about to remove, and leaves the two empty pouches passed one within the other, and, in some cases, connected by suture, to form new bone. The suggestion is undoubtedly theoretically sound. Its practical value remains, however, to be proved. In two of the three cases which Jordan records, it failed of success; and he admits its failure in the hands of M. Sédillot.[5]

In an ununited fracture of the humerus, Hunter effected a cure by opening the synovial cavity, and irritating its interior with a spatula.[6] This is the only case of the kind on record; but scraping the fragments, originally suggested by White, has been occasionally adopted independently of resection. The results are not encouraging. Failure has been more frequent than success, and twice the operation has been fatal.[7] Brodie plugged the wound with lint, and failed; but his proceeding has been successfully imitated by Davis.[8]

[1] Laugier, Mém. read to Acad. des Sciences, April, 1855.

[2] Journ. de Méd. Clin. et Phar., vol. x., p. 195.

[3] Laloy, "De la Suture des Os," etc., Thèse inaug., Paris, 1839.

[4] "Resection de la Mâchoire inf.," in Leç. Or. t. iv., p. 658.

[5] Traitement des Pseudarthroses par l'autoplastic périostique, Jos. Jordan, Paris, 1860.

[6] Referred to by Brodie on the authority of Home. See also Hunter's Works, Palmer's ed., 1835, vol. i., p. 504.

[7] In one of these a seton was used also. See Malgaigne's Traité, sup. cit., p. 317.

[8] Lancet for Feb. 5, 1859.

Cauterization is a less dangerous operation, though not often employed. Different caustics have been used; caustic potash, which is the best, by Cline,[1] Earle,[2] and others; nitric acid by Ollenroth;[3] chloride of antimony by White and Weilinger;[4] nitrate of silver by Kirkbride.[5] In one of Earle's cases and in White's, there was a slight exfoliation of bone; but this is not usual. Cauterization is most applicable to old cases, when the fragments are covered with fibro-cartilage, or with a genuine false joint.

A mild species of actual cautery was used by Mayor[6] on the femur. He passed several times between the fragments a steel probe heated in boiling water. It produced profuse suppuration and union. The actual cautery was once used by Petit.

In a case of non-union of the humerus, in which there was a fistulous opening, Hulse[7] found the daily injection of a stimulating liquid of service, both to hasten the separation of the dead bone and to stimulate the growth of new.

In 1845 Dieffenbach introduced an operation which bids fair, in most cases, to supersede the severer measures just noticed. Taking advantage of the fact pointed out by Duhamel and Flourens, that inert foreign bodies lodged in bone become surrounded by abundant osseous deposit, he drills three or four holes, penetrating as far as the medullary canal, near the end of each fragment, into which he forcibly drives ivory pegs. The pegs, projecting from the bone, are left from ten to twelve days or more; that is, till their presence has given rise to considerable swelling. Union is completed in from ten to twelve weeks. Dieffenbach himself appears to have met with great success from this operation, even on the humerus and femur.[8] In England it has been performed successfully on the femur, tibia, humerus, and ulna.[9] It has, however, met with reverses. The first time it was tried, by Square[10] of Plymouth, on the femur, it utterly failed. The case,

[1] South's Transl. of Chelius's Surgery, vol. i., p. 591.

[2] Med.-Chir. Trans., vol. xii., p. 190.

[3] Bernstein, Ueber Verrenkungen, etc., p. 280.

[4] Rust's Magazin, vol. xxxiv., p. 330.

[5] Amer. Journ. of Med. Sci., Feb., 1835.

[6] Nouveau Système de Déligation, etc., Geneva, 1832.

[7] Amer. Journ. of Med. Sci., Feb., 1834.

[8] Dr. Bushnan's report in Med. Times and Gazette, vol. xv., 1847, p. 298.

[9] See Lancet, 1851, vol. ii., p. 344; 1852, vol. ii., pp. 152, 154; 1855, vol. ii., p. 279; also British Med. Journ., 1859, p. 885.

[10] Med. Times and Gazette, 1851, vol. ii., p. 300.

however, was a most unfavorable one, and eventually the limb had to be amputated. Bowman[1] also failed in the leg, in a case equally unfavorable from excessive deformity. The operation has been followed, in different cases, by fever, erysipelas, hemorrhage, and profuse suppuration, but does not appear to have been fatal, offering, in this respect, a favorable contrast to resection, due probably to the circumstance that it does not expose the end of the medullary canal. In one case[2] the operation on the femur was followed by union, leaving, however, a sinus, and succeeded, some weeks later, by erythema, profuse suppuration, and hectic, necessitating amputation.

In an operation on the femur, Stanley connected the fragments by a silver wire, in addition to inserting the pegs.[3] The result is not given.

The above operations are practically divisible into two classes: those which are followed by suppuration, and those which are not. The latter must, of course, in all cases in which they are likely to be sufficient, take precedence. The circumstances by which the selection must be guided are the situation and condition of the false joint, and the length of time that has elapsed since the fracture. Special indications have been noticed under the individual operations. Apart from them, where rest and friction, aided, if possible, by external stimulants, have been found insufficient for the cure, Miller's or Brainard's operation deserves the first trial; next to that, some form of seton; and, as a last measure, Dieffenbach's operation. In the humerus and femur it will generally be advisable to omit the seton, and pass at once to Dieffenbach's plan. If the fragments are covered by a very dense tissue, it may be removed, as an accessory measure, either by the knife or by caustic.

It is to be observed that no severe operation will be justifiable unless the inconvenience resulting from non-union is considerable. In some cases, as in the ribs, it is of no practical consequence. In others the new joint supersedes an old one. This has happened after a fracture two inches above the elbow,[4] and frequently in the neck of the femur. In others, the slight inconvenience is easily and abundantly remedied by an artificial support. Larrey, indeed, recommends this course to be adopted whenever the simple means of cure fail.[5] In a few cases, where a lost portion of the tibia has not been restored, as in three witnessed by Sir A. Cooper, its place has to a great extent been supplied by a large increase of the fibula.

There are a few cases in which, in consequence either of hectic, or of the great encumbrance of a useless limb, on which all operations have failed, amputation is the only resource.

Diseased and deformed union.—The new bone is of course liable to all the diseases of bone. The two most frequent and most troublesome are long-continued pain, analogous to the neuralgia of cicatrices in soft parts; and excessive exuberance, the result of ostitis.[1]

There are three species of deformity resulting from mal-union: 1. Junction with permanent displacement, either angular or rotary, or shortening. 2. Union of two contiguous bones. 3. Projection of one of the fragments.

For the removal of the first kind of deformity four methods have been devised: reduction by means of extension and compression, refracture, section, and resection.

Extension is made, as in the original reduction of fractures, by the hand, or by the assistance of lacs and pulleys, or, gradually, by means of splints. Compression, too, may be applied gradually or suddenly. Gradual compression is made by splints or special apparatus. A splint may be placed opposite the concavity of the angle, and the bone drawn towards it; or it may be fixed to one fragment on the convex side, acting as a lever to which the other is to be drawn; or the projecting angle may be pressed between two opposing splints. The bandages must be repeatedly tightened. Special apparatus of curved splints, straps, and tourniquet-pads have been used, but are rarely, if ever, necessary.[2]

The apparatus, combining pressure and extension, must be worn for from twenty-one to twenty-eight, or even forty days. Sometimes it is sufficient, after two or three weeks, to continue extension alone. By this treatment deformity has been remedied in numerous fractures: in some of twenty-five, twenty-nine, fifty-nine days', or even as much as four or five months' standing. Dupuytren thinks that the union will not yield to extension beyond the sixtieth day; but pressure may be of use much later.[3]

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[1] Lancet, 1852, vol. ii., p. 153.
[2] Edin. Monthly Journ., March, 1854.
[3] Stanley, Lancet, 1854, vol. i.
[4] Med. Times and Gaz. 1851, vol. ii., p. 221.
[5] Clin. Chirurg., vol. iii., p. 461.

[1] "Des Accidents consécutifs aux Fractures," par M. Guyot, in Arch. de Méd., Feb., 1836.
[2] Jacquemin, Thèse inaug., Paris, 1822.
[3] "De la Formation du Cal: Moyens de remédier au cal vicieux ou difforme," Leç. Orales, t. iv., art. 5, p. 130.

Sudden forced compression has been sometimes employed; but, except in those cases where it has been used at a comparatively early period, it appears to produce a species of partial fracture. Where reduction cannot be obtained at the first trial, it may be repeated in two or three days.[1]

Refracture is effected gradually, during extension, pressure being made either by the hands or knee, or, in difficult cases, by a screw-press.[2] Skey managed it readily by leaning the weight of his body on the end of the limb, projecting beyond the edge of a board or bed. The fracture is facilitated by bending the limb alternately in different directions, and, when there is only one bone, by rotation. The old practice of breaking it by a hammer, or by sudden pressure across a stick, is justly discarded.

The time during which a united bone admits of refracture varies greatly, even to the extent of many weeks. It depends on the age and health of the patient, the extent of uniting surface, the position of the fragments; in fact, on all those circumstances, which influence the rapidity and perfection of the healing process. The cases of deformity for which the operation is required are the very cases in which union is ordinarily most protracted; and long after it is sufficiently firm to admit of free use of the limb, it may be dissolved by force without difficulty. Moreover, in young subjects, in whom these deformities are most frequent, refracture is attended with the least difficulty. Œsterlen, however, did not attempt it in any case beyond the twenty-fourth week;[3] and Bosch, in spite of the power of his screw, recommended six or six and a half months as the extreme limit. But Skey operated once on the leg, in a boy æt. 15, thirteen months after the fracture.[4] In that case he found it necessary to divide the tendo Achillis before he was able to make extension, and even then the limb remained shortened to the extent of three-quarters of an inch.

Four objections have been raised to this operation. 1. The danger of breaking the bone in the wrong place. Œsterlen and Skey, however, show that this danger is chimerical, the new bone being for many months more spongy and more fragile than the old. This dreaded accident has never happened; and, moreover, accidental refracture, which has taken place in some cases after two or three years, is always in the same place as the first, and the same has always occurred in experiments on animals. 2. The fear of inflammation and abscess, in consequence of laceration of the periosteum and soft parts. But all such accidents have been safely overcome in the first fracture, when they were necessarily more severe. Skey refers to a case in which, without effecting his purpose, he had recourse to considerable violence; the only evil effects of which were slight bruising and stiffness, which passed off in two or three days. 3. The separation of the fragments by an interval which could not be filled by bone. The cases are very few, however, to which this objection could apply, and even in them considerable amelioration of the deformity might be effected. 4. The fear that, in cases of overlapping, the cicatrized ends of the fragments will be incapable of uniting. This fear, however, is unsupported by facts; the deformity is not commonly accompanied by deficiency of healing power; and in many cases the new fracture has appeared to unite even more readily than the old.

The operation has not always been free from danger. Cases fatal from its violence are recorded by Guy de Chauliac Morgagni,[1] and Laugier.[2] Of course it is justifiable only when it is indispensable to the utility of the limb, when it can be undertaken without difficulty or danger, and the deformity was attributable to causes which can be avoided in the treatment of the second fracture, and only after all practicable means of reduction by extension and compression have been tried without success. With these restrictions, it may be resorted to, in the upper extremity, when shortening of the forearm is accompanied by loss of muscular power and inability to rotate; in the lower extremity, for extreme lameness, either from shortening or angularity; and, in either limb, for deformity accompanied by severe permanent pain, the result of pressure or displacement of nerves, and not amenable to other treatment.

If the union is too solid to admit of rupture, it may be divided by cutting. This has been done more than once. It is, of course, a serious operation, only justifiable in extreme cases of deformity. It was performed successfully on the tibia

[1] A. Thierry, "Du Redressement des Os fracturés," L'Expérience, Nov., 1841.

[2] As used by Bosch, of Augsburg, described by Œsterlen.

[3] Sur la Rupture du Cal, ou Méthode sûre de rompre les Os mal réduits, par J. F. Œsterlen, traduit de l'Allemand par J. C. Maurer, Paris, 1828.

[4] "Cases of Refracture of Bone," Med.-Chir. Trans., vol. xlii., p. 23.

[1] De Sed. et Causis Morb., epist. lvi.

[2] "Des Cals difformes et des Opérations qu'ils réclament," Thèse du Conc., 1841, p. 62.

by Key and A. Cooper in 1839. Quite recently Lister has recorded a very successful operation of the kind on the leg. A fracture of both bones, two inches above the ankle, had united with great displacement of the foot backwards and eversion, rendering the limb absolutely useless. Trusting to the antiseptic treatment to obviate the great risks of producing a compound fracture into the ankle joint, he cut down on the bones, and having divided them with cutting pliers, restored the foot to its proper position, which, however, he was unable to do till he had divided the tendo Achillis, the muscles of the calf and of the sole of the foot being contracted through the long-continued displacement. Fresh union of the bones followed in about six weeks.[1]

[The subcutaneous osteotomy advocated by Adams of London, may in very many cases be advantageously substituted for the measures already referred to. It is free from the risks attendant either upon forcible breaking up of the union or upon section. Details as to its performance will be found elsewhere in this work, and the simplicity of it will make its adaptation easy to almost any portion of the skeleton.]

Resection of one or both fragments has been rarely resorted to. M. Clémot removed an angular piece of bone from a deformed femur in an infant of forty days old.[2]

Union of contiguous bones may take place in the forearm, the leg, or between the ribs. In the leg it is of course unimportant; and in the ribs, though an impediment to free respiration, it cannot be touched. In the forearm it might be remedied by rupture or section; but it does not appear that more than one instance of such an operation is recorded.[1]

The projecting point of one of the fragments may be the source of much irritation and inconvenience. Generally such projections are removed by absorption; but occasionally it is not so. They may in that case be removed by the saw or nippers. A few operations of the kind are mentioned by Velpeau,[2] Dunn,[3] and others.

[Cases are sometimes met with in which nerve-trunks are either entangled in the callus or pressed upon by a badly-united fracture. Such conditions sometimes admit of remedy by operation, but are occasionally very obstinate. The following may be cited as an instance:—[4]

The report of the Société de Chirurgie contains a communication by M. Delens of a case in which, three or four days after the removal of the apparatus from a very mobile fracture of the humerus in a man æt. 37, radial paralysis was noted. Electrization having given no result, the nerve was exposed by incision, and found clearly entangled (*enclavé*) in the callus. "However, it was only enclosed in three-fourths of its circumference, the other fourth being covered by a mere fibrous band. In order to disengage it, it was necessary to lift (*faire sauter*) an osseous lamella 5 or 6 millimétres in thickness. Numerous spiculæ of bone encrusting the nerve had also to be removed." The improvement ensuing upon this procedure was only temporary.]

DISLOCATIONS.

By T. Holmes, Esq.

Revised by John H. Packard, M.D.

The term "dislocation" is etymologically equivalent merely to "displacement;" but in surgery the use of the word has been restricted to the displacement of one articular surface of bone from another;[3] and it would perhaps be more convenient still further to narrow the meaning of the term, so that it should include only such of these displacements as

[1] Brit. Med. Journ., Oct. 31, 1868, p. 462.

[2] Clémot, Mém. sur la Resection du Fémur, Acad. de Méd., 1836.

[3] Occasionally, it is true, the term "dislocation" is applied to the displacement of soft parts. Thus we talk of "dislocation of the crystalline lens," "dislocation of the testicle into the perineum," "dislocations of tendons from their grooves," etc. This use of the word, however, can hardly create ambiguity.

[1] By Gardeil; quoted in Malgaigne's work, sup. cit., p. 342.

[2] Méd. opér., 2d ed., t. ii., p. 599.

[3] Med.-Chir. Trans., vol. xii., p. 167.

[4] [Gazette Méd. de Paris for May 15, 1880.]

are caused by violence. This restriction, however, has not yet been made; hence dislocations are divided into three classes — congenital, pathological, and traumatic. The first are malformations, which, if they are treated at all, must be attacked in early life. Their consideration is therefore deferred to the section on the SURGERY OF CHILDHOOD. The second are symptomatic of various diseases of the joints, in which the displacement of the articular surfaces, though of the highest practical importance, is pathologically non-essential. They will be found discussed in the essay on DISEASES OF THE JOINTS. The third only form our present subject.

A traumatic dislocation, then, is a forcible separation of the articular surfaces of two or more bones. This is effected by the rupture or stretching of their ligaments, and may be *partial*, *i. e.*, when parts of the articular surfaces remain in contact with one another, though not the parts naturally opposed; or *complete*, when the surfaces are not in contact by any part. Another classification of dislocations which it is necessary to dwell upon is, into *simple*, in which the dislocated bone is not exposed to the air; and *compound*, where there is a wound communicating with the injured joint.

The various special dislocations, *e. g.*, of the hip, shoulder, etc., are described further on, with the injuries of the regions in which they severally occur; it is, therefore, only necessary here to state the general principles applicable to the pathology and treatment of Traumatic Dislocation.[1] Complete dislocations will be first spoken of, as affording the most intelligible and perfect examples of the injury; and the consideration of compound dislocations will be reserved till the principles which guide surgeons in the treatment of the simple injury have been described.

Causes.—The causes of dislocation, as of fracture, are twofold; external violence, and muscular action. The latter, however, is in the healthy state of parts, very rarely the cause of dislocation, while (as above shown, p. 481) fractures from this cause are less uncommon. Many instances, however, have been put on record, in which the humerus has been dislocated by the action of the muscles only; and of this accident the present writer saw once an example in the case of a patient who was lying in bed on account of another injury. In making some sudden movement of his right arm, the precise nature of which he could not afterwards explain, the humerus slipped out of the socket. No difficulty was experienced in reducing it. In this patient the bone had never been dislocated before; but in cases of old dislocation, especially when the original treatment has not been sufficiently prolonged, the injury is very often reproduced by mere muscular action, and then the bone is just as easily reduced. Many persons in whom the shoulder is so affected, have learnt to reduce the dislocation for themselves, by reaching over a gate, taking hold of one of the lower bars, and hanging in this position, when the mere weight of the body is sufficient to restore the parts to their place. There is one dislocation which is almost always produced by muscular action, that of the lower jaw, and the dislocation of the patella is very commonly so caused.

[Spontaneous dislocation is sometimes, but rarely, met with in cases of asthenic disease. I have seen one such instance, in which luxation of the humerus occurred in the course of typhoid fever.]

Much has been said by systematic writers about the share which the muscles take in the production of the common dislocations from external violence, *e. g.*, those of the hip and shoulder. There is, however, little practical importance in the question, though it is interesting physiologically, from its application to animal mechanics. It is not probable that the muscles have any other influence in producing most dislocations, than that they sometimes fix the bone on which they act in positions in which the external force acts advantageously upon it. But since, as M. Malgaigne observes, most dislocations can be produced in the dead body as easily as in the living, it is clear that the action of muscles is a very unimportant element in such accidents.

A less doubtful effect of muscular action is the change which is often produced in the position of the displaced bone during the first few days after the accident; so that a bone which has been thrown into a certain position at the time of the injury may afterwards be found in another place. Thus the head of the femur is often drawn from the dorsum ilii into the sciatic notch; and the reverse of this sometimes occurs. Such dislocations are sometimes called consecutive. The action of the muscles is aided perhaps, in some cases, by the weight of the limb.

Symptoms.—A complete dislocation is, in typical cases, attended with such very distinct symptoms, that when these are fairly detailed upon paper the reader is tempted to say that the injury is unmistakable. Yet the great number of old

[1] For the sake of simplicity and to avoid repetition, the word "traumatic" will be dropped in the sequel; but all that follows must be understood as spoken only of that form of dislocation.

unreduced dislocations which are still seen, even in patients who have been from the first under medical supervision, proves that, notwithstanding the elaborate care with which the symptoms of dislocation in general, and of each special injury in particular, have been described ever since the time of Astley Cooper, such mistakes cannot always be avoided, even by well-informed and careful men; and it is no doubt true that errors in diagnosis on this head will sometimes occur to the best surgeons, in consequence of extreme depth of the parts, of great effusion and swelling over them, or of complication with other injuries; but with proper care such mistakes ought to be very seldom made even at the time of the accident, and attention to the subsequent progress of the case will always enable the surgeon to correct his error while there is yet a fair prospect of easy reduction.

The general symptoms of dislocation are, sudden loss of motion, following an injury which (except when the joint has been formerly the seat of a similar lesion) is usually severe; loss of the natural shape of the parts, from changes in the relations of the muscles surrounding the joint, and the altered position of the bones; change in the length of the limb, which in the great majority of dislocations is shortened; loss of the power of voluntary motion, except to a limited extent and in certain directions; absence of crepitus when the limb is manipulated; and great interference with passive motion, especially in certain movements; while, on the other hand, other passive movements limited or impossible in the healthy body may be absolutely unimpeded, in consequence of the rupture of the ligaments which before restrained them. Other symptoms, accompanying particular dislocations, and depending on interference with the functions of viscera, nerves, or vessels pressed upon or lacerated by the displaced bone, may be present and may assist in diagnosis; but they need not be further alluded to in this place.

Crepitus is sometimes met with in dislocation, and that from three causes: 1. The ordinary pseudo-crepitus is a crackling sensation, due to the presence of fluid in the joint-cavity, the sheaths of the tendons, or neighboring spaces, easily distinguished from true bony crepitus. This is comparatively often met with some time after the accident. 2. True bony crepitus may be perceived at any time, if the displaced head of the bone rests on a fractured process in the neighborhood, as in a case reported by the present writer in Med.-Chir. Trans., vol. xli., where the head of the humerus rested against the stump of a fractured coracoid process. 3. Finally, there are a few cases in which, as it appears, the soft parts separating the displaced head from the surface of bone on which it rests have become absorbed, and these surfaces of bone, roughened by inflammation, crepitate harshly when rubbed together. This cannot occur till some days after the accident, at the earliest.

Pathological anatomy.—In a complete dislocation, the injury is not confined to the bones and ligaments only, but involves more or less lesion of the surrounding parts. The articular capsule is usually widely lacerated, and the special ligaments of the joint torn in various degrees. In partial dislocation it seems probable that this feature may be absent, the capsular and other ligaments being merely put on the stretch; but it must be confessed that our knowledge of these injuries is not as yet very perfect. Mr. Wormald has related a case[1] where a partial dislocation of the hip, with fracture of the acetabulum, appears to have been the original accident, and where the ligamentum teres remained untorn; and Mr. Soden's case of (supposed) partial dislocation of the humerus upwards from displacement of the long head of the biceps is well known;[2] but, from the length of time which has passed in most of these cases between the injury and death, it is impossible to form from them an opinion as to the usual condition of parts at the time of the accident. Even in cases of complete dislocation, however, we may admit the possibility of simple stretching of the capsular ligament, without rupture, though perhaps we might not be able to refer to any preparation or history which proves this beyond doubt. There is a preparation (No. 868) in the Museum of the College of Surgeons, showing the dissection, by John Hunter, of a shoulder-joint three weeks after reduction of a dislocation, in which he believed that the capsular ligament had not been torn, but merely stretched or bruised. There was, however, some trace of injury to the membrane still perceptible; and it must be allowed to be possible that it might have been lacerated at the time of the accident, and afterwards have united. [Mr. Eve[3] reports a case, proved by autopsy, of sub-coracoid dislocation of the humerus without rupture of the capsule, which was however detached from the anterior margin of the glenoid cavity. Death in twelve hours from other injuries.] The case of dislocation of the bones of the foot from the astragalus, reported by Mr. Pollock,[4] shows the extent

[1] Medical Gazette, vol. xix.
[2] Med.-Chir. Trans., vol. xxiv., p. 212.
[3] [Med. Times and Gazette, May 23, 1880.]
[4] Med.-Chir. Trans., vol. xlii., p. 43.

to which ligaments may be stretched without absolute rupture. The os calcis was so movable on the astragalus that the sole of the foot could be turned vertically inwards; yet the interosseous ligament, though stretched, was not completely ruptured.

Besides the injury to ligaments, a variable amount of damage is frequently done to the surrounding muscles, which are torn away from their attachments, lacerated, or stretched, according to the nature and extent of the displacement. The great nerves in the neighborhood (such as the circumflex in the shoulder) are often compressed or lacerated, and hence severe pain at the time of the accident, and paralysis afterwards of the parts supplied by those nerves, which is sometimes irremediable. The large vessels almost always, in simple dislocation, escape without injury;[1] but they are sometimes compressed by the displaced bone, so as to obstruct the circulation through the limb. Fracture of some of the processes surrounding the joint is a very common complication. In fact, in some joints (as the ankle) it is rare to find a pure specimen of dislocation. The only importance of this fact is, that in such cases more care should be taken to procure and maintain exact apposition.

Such are the immediate effects of a dislocation. If the bones be restored to their natural position, all these injuries are generally soon repaired. The ruptured capsule readily heals, the injured muscles and tendons regain, in a great measure, if not entirely, their former condition and their former strength, and even the nerves, if contused or lacerated, may slowly recover themselves. It may, indeed, happen, although it is not common, that the joint inflames after reduction, even under proper and judicious treatment; but this complication need not be further dwelt on here, since it must be treated on the same principles as any other case of articular inflammation after injury.

If the dislocation, on the contrary, has been neglected, or if it has been found necessary to abandon its treatment, further changes necessarily follow. These changes, like almost all other morbid phenomena, are principally efforts after the repair of the injury. The chief of them all is the formation of a *new joint*. The head of the dislocated bone forms for itself a cavity on the bone upon which it is thrown; a cavity which is caused partly perhaps by inflammatory softening and the removal of some of the original bone, but principally by deposit of new bone on the surface of the latter. These new cavities are found lined by a substance which to the naked eye closely resembles cartilage, but which, under the microscope, shows the structure of fibrous tissue. The original articular cavity at the same time gets filled up with a fibroid deposit, and the head of the bone is surrounded in its new position by a cyst or new articular capsule formed from the surrounding areolar tissue. At the same time the displaced bone may suffer various changes of form, from inflammatory softening and ulceration, by which its shape and size will be essentially altered. These observations apply almost entirely to joints resembling the ball and socket, in which an articular head is dislocated on to a flat bone. In ginglymoid and arthrodial articulations the process of repair will be much less extensive, and therefore the resulting recovery of motion much less perfect. Sometimes, indeed, in small joints of this kind, such as those of the fingers, complete bony anchylosis may follow.[1]

The consequences of an unreduced dislocation, however, are not limited to the bones which are displaced, since the altered position of the soft parts and the irritation set up, somewhat in the manner of a foreign body, by the displaced bone, materially impede the function of the muscles. The tendons may have been carried away from their points of attachment and united to some part which is partially or entirely immovable; or (as is often the case with the long tendon of the biceps) they may have been split longitudinally and thereby much weakened, though a part retains its natural connections. As a consequence of these injuries, and of the inflammation which follows them, adventitious formation of bone is sometimes found in the tendons and in the other fibrous structures around the joint; another particular in which the consequences of old dislocation resemble those of chronic rheumatic arthritis, and therefore a fresh difficulty in the diagnosis of the two affections.[2]

[1] A case was operated upon by Professor Goldsmith, of Louisville, in which the femur had been dislocated on to the brim of the pelvis, so as to lie under the femoral artery. It remained unreduced for two months, when a diffused aneurism was found to have been formed. The common iliac artery was tied. The patient died on the fifth day. The femoral and external iliac arteries were found perforated to the extent of an inch on the posterior external aspect; and the head of the femur lay in the cavity of the aneurism. (American Journal of the Medical Sciences, July, 1860, p. 30.) In dislocations of the shoulder also the axillary vessels are occasionally injured.

[1] Preparations showing this condition may be found in the Museum of St. Bartholomew's Hospital, Series III., Nos. 57, 61.

[2] Specimens in which a deposit of new bone

Various causes may combine to produce adhesion between the bones. The articular cartilages will in all probability be absorbed, either as a consequence of inflammation (*e. g.*, when the head of the bone has been resting against a prominent process or the stump of a fracture),[1] or from the atrophy which removes parts whose function is lost. The very completeness of the reparative process may sometimes be the cause of permanent loss of function to the joint. Thus in a case of unreduced dislocation of the radius, preserved by the writer in the Museum of St. George's Hospital, the orbicular ligament is seen to have been carried away with the head of the radius, and is firmly united in this position by both its ends to the humerus as well as to the radius, thereby binding these bones firmly together, and entirely preventing rotation. The great tendons sometimes form bands of adhesion between the bones. This is again illustrated by a specimen of dislocated elbow in the same museum, where the brachialis anticus, torn off the coronoid process, which is carried into the olecranon fossa, has become firmly united, both to the trochlear surface of the humerus, and to the ulna below its original attachment, so as to form a kind of soft anchylosis between them.

It seems probable that in some cases the edges of the rent in the articular capsule may unite either partially or completely, so that the hole which admitted the passage of the bone out of the joint will no longer allow it to go back again.[2] Professor Fabbri believes that the head of the bone which has been dislocated may be prevented by the laceration of the capsule being somewhat too little, or by the interposition of other soft parts, from returning entirely into the articular cavity when reduction is first attempted, and that thus a dislocation originally complete may become incomplete.[3]

It is also noticed by Professor Hamilton[4] that the great vessels sometimes become adherent to the capsule or periosteum of the displaced bone, leading to the risk of fatal hemorrhage should forcible attempts be made to effect reduction.

Such are the principal effects of unreduced dislocation. Other pathological changes may doubtless be observed; but the scope of the present work does not admit of detailed notice of mere pathological curiosities, and the reader who desires to follow the subject more minutely must consult special treatises. The chief importance of the study of these changes is in order to know the time at which they occur, so that the justifiability or otherwise of attempts at reduction a given time after the accident may be determined. Alteration in the shape of the bones, either by widening of the articular cavity or absorption of the head of the bone, may render permanent and safe reduction hopeless;[1] or deposit of new bone on the dislocated head may render it too large to fit the cavity; or the presence of soft anchylosis between the bones (either as a consequence of inflammation or of the vicious union of ruptured ligaments or tendons) may render necessary for reduction a force greater than can safely be applied;[2] or the original articular cavity may be filled up with lymph or with the remains of the old capsule; or the articular cartilages may have been absorbed, so that no healthy joint could be reproduced.[2]

So that, in determining the question of the justifiability of attempts at late reduction, it is material to know the period at which these changes occur. Unfortunately nothing is more difficult, since patients are not often kept under observation so long after the accident, and therefore the history of the case is rarely known. Most of the preparations in our museums are quite devoid of histories, and the greater part of them show the state of things at a time when all question of treatment must have long been abandoned. It is clear, however, that the formation of a false joint goes on in some cases with considerable rapidity. Thus in Mr. Hilton's case, previously mentioned (see note on this page), the patient died of another disease thirteen weeks after the accident; the only reduction possible still left the head of the bone external to the capsular ligament. Mr. Hilton says:

in tendons is believed to have followed dislocations may be found in the Museum of Guy's Hospital, Nos. 1297[50], 1298[50].

[1] Med.-Chir. Trans., vol. xli., p. 450.

[2] See a case related by Mr. Hilton, Guy's Hospital Reports, Series II., vol. v., p. 96; a preparation in the Museum of St. Bartholomew's Hospital, dissected three weeks after the accident (Ser. III., No. 20); also a case by Hamilton, of the United States, American Journal of the Medical Sciences, Nov., 1837, p. 47 (quoted by Malgaigne, op. cit., p. 53); and a case by Hamilton, of Dublin, presented to the Dublin Pathological Society, Nov. 28, 1868. In the latter case, however, there was some fracture of the articular cavity.

[3] Memorie della Società Med.-Chir. di Bologna, vol. ii., p. 629.

[4] On Fractures and Dislocations, Philadelphia, 1860, p. 492 [1880, p. 587].

[1] Mr. Curling relates a case in Med.-Chir. Trans., vol. xx., p. 338, in which insecurity of reduction was occasioned by absorption of the glenoid cavity.

[2] The deposit of bone in the tendons probably does not take place till a time at which no prudent surgeon would think of endeavoring to reduce the dislocation.

"All these parts (viz., the head of the humerus; the remains of the original capsule, now interposed between it and the glenoid cavity; the fractured great tuberosity, and its attached muscles) were included by a thin new fibro-cellular capsular ligament, and the surfaces contributing to the formation of the new joint were all smooth, and covered, as it were, by a new adventitious synovial membrane." In M. Malgaigne's work[1] a case is cited in which similar changes were discovered eighteen days only after the accident. Several other interesting cases will be found in the same work; but the cases hitherto published are far too few to form a scientific foundation for any general conclusions. And, on the other hand, several cases have been put on record in which dislocations have been successfully and permanently reduced at a time much beyond that which is laid down in most of our standard works. Thus, even before the introduction of chloroform, M. Sédillot succeeded in reducing a backward dislocation of the shoulder more than a year after the injury.[2] Dieffenbach is said to have reduced a dislocation of the shoulder two years after the accident, Breschet one of the hip on the seventy-eighth day; and Mr. Brodhurst relates two cases, in one of which he succeeded in reducing a dislocation of the shoulder on the one hundred and seventy-fifth day, and in the other a dislocation of the wrist, six years after the accident.[3]

Diagnosis.—On the subject of diagnosis hardly anything need be said in this place. The only injuries with which dislocation can be confounded are, (1) simple contusions and sprains, and (2) fractures near the joint, or separation of epiphyses. The diagnosis in the first case is made by recognizing the positive symptoms of a dislocation instead of the negative symptoms which imply its absence; and as to the second, the diagnosis between fracture and dislocation has been already discussed (see FRACTURES, p. 487). Separations of epiphyses are distinguished from dislocation by the following characters: 1. The former can only occur at ages at which the epiphyses are separate from their shafts; the latter at any age. 2. The former are, as a rule, easy to reduce, and difficult to retain; in the latter, as a rule, these conditions are reversed. 3. In the former, the points of bone immediately surrounding the joint preserve their normal relations; in the latter, these relations are variously altered. 4. The sensation perceived in the two injuries is different, for separation of an epiphysis is usually complicated with fracture, and therefore crepitus can be elicited. Perhaps it may be added, that an error in diagnosis would be rather mortifying to the surgeon than prejudicial to the patient, since the general indications are the same.

Treatment.—When the diagnosis has been established, if the injury is recent and the patient is suffering much pain, reduction should be at once attempted—at least, this should be the rule in all joints except the hip, where it is perhaps better to wait until chloroform [ether] and some extending apparatus can be procured, in case either the one or the other should prove necessary; and in some of the smaller joints, when the patient does not suffer much, we may be guided by circumstances whether to attempt reduction immediately or put it off till some more convenient time and place. There is always a fair chance of reducing a recent dislocation, without any appliances or assistance; although, from peculiar complications, or from the great muscularity of the patient, failure may occur in almost any. The principles of reduction are very simple, and the various mathematical and anatomical refinements, with which the ingenuity of systematic writers has surrounded the subject, are never thought of in practice. The process is as follows: 1. The upper end of the limb must be fixed; 2. The lower end must be pulled in the most advantageous direction (reference being had to the insertion of muscles into it, and to the shape of the parts on which the displaced head is lying), until by this extension the limb has been restored to its proper length; and then, 3. The displaced bone or bones must be directed into the joint by manipulation or traction. [It may perhaps be best said here, that in the case of the shoulder, hip, and ankle, it is often possible to effect reduction without any pulling at all, but simply by movements of flexion, extension, and rotation. The special methods will be detailed in connection with each of these joints.]

The second is the most difficult indication to fulfil. In the majority of recent and simple dislocations, all that is necessary is to know the anatomy of the parts, and the rules applicable to the special injury under treatment, which will be found in subsequent sections of this work, and to make manual extension in the manner indicated by those rules. But in more complicated and less recent cases something must be done to relax or subdue the

[1] Op. cit., p. 52.

[2] Contributions à la Chirurgie, vol. i., p. 132.

[3] "On the Reduction of Old Dislocations," St. George's Hospital Reports, vol. iii., p. 68.

muscles. It was formerly considered necessary for this purpose to reduce the powers of the system by venesection and tartar-emetic; but this treatment has now been entirely superseded by the discovery of chloroform [and other anæsthetics]. In no part of operative surgery has this great discovery made a more complete revolution than in the treatment of dislocation; so that what was frequently a most difficult, and always a very painful operation, has now become comparatively painless, and usually quite easy. The rule, therefore, in all dislocations which cannot be reduced by the first attempts which the surgeon makes with his own unaided force, is to administer chloroform; having the necessary apparatus at hand for making forcible extension, if required. The only exceptions to this rule are, when, from concomitant disease or injury, chloroform is in the judgment of the surgeon contra-indicated. But these reasons act also to contra-indicate all forcible attempts at reduction; for should the contra-indication be a diseased state of the heart,[1] this condition would also forbid a forcible, prolonged, agitating, and painful operation; and if the complication of other injuries renders it unadvisable to give chloroform, no objection exists to waiting until the effects of such injuries subside before attempting reduction.

In old times, the muscles used to be overcome by the prolonged traction of a number of men, or by various mechanical contrivances, some of them of the most ludicrous nature, which may be seen described in old books of surgery. For these paraphernalia a later age has substituted the *pulleys*, a most valuable machine, and one still indispensable to the treatment of dislocation, though less frequently called into play since the discovery of chloroform than it used to be.[2] It consists of a system of pulleys on a single string; an arrangement by which the force is multiplied by the number of the strings on the lower block. The pulleys are attached on one side to a staple driven into the wall, and on the other to a bandage of leather firmly bound to the limb, and usually to that segment of it which is dislocated, instead of to the one below, *e. g.*, above the elbow in a dislocation of the shoulder rather than below. The limb above the dislocation is fixed, by means of another stout leather bandage, to a staple opposite the former. Having seen that the string of the pulleys runs freely, and that the bandages are all in their proper places, the surgeon confides to one assistant (if he have two) the care of the upper bandage, to see that the patient's body does not get dragged out of place by the force which is to be applied, and to the other the string of the pulleys. This string, having been made so tight that the upper bandage is visibly pulled upon, is then to be cautiously and gradually tightened, a small piece being pulled in at regular intervals. In France, an instrument called the dynamometer is attached to the pulleys, in order that the precise force used may be accurately measured. Meanwhile the surgeon manipulates the head of the bone; and when it appears to him that the force has acted sufficiently upon it, *i. e.*, when it has come opposite to the empty articular cavity, he gives the word to his assistant to drop the string of the pulleys; and then, without the loss of any time, directs the head of the bone into the articulation, either with his hands or with a lever of some kind passed below it. Should this attempt fail, it may be renewed, or the limb may be bandaged in the position which it has now assumed, and a fresh trial made on the next or some early day. It is frequently advisable in old dislocations, where the displaced bone has contracted adhesions, to limit the first extension to breaking down these bands, postponing all efforts at complete reduction till another opportunity. Reduction having been accomplished, the position of

[1] The reader will observe that no opinion is here expressed on the correctness of the opinion that disease (whether valvular or degenerative) of the heart is an absolute contra-indication to the employment of anæsthetics.

[2] Cases will occur when the pulleys are not at hand, and then the assistance of several men, to make extension and counter-extension, must be employed. Great care should be taken to make them pull together gradually and steadily. Or the following contrivance, described by Dr. Gilbert, of Philadelphia (v. Hamilton, op. cit. [1st ed.], p. 494), may be used. "Place the patient, and adjust the extending and counter-extending bands as for the pulleys; then procure an ordinary bed-cord or a wash-line; tie the ends together and again double it upon itself, pass it through the extending tapes or towels, doubling the whole once more; and fasten the distal end, consisting of four loops of rope, to a window-sill, door-sill, or staple, so that the cords are drawn moderately tight; finally, pass a stick through the centre of the double rope, then by revolving the stick as an axis, or double lever, the power is produced precisely as it should be in such cases, viz., slowly, steadily, and continuously."

Other instruments have been proposed for making forcible extension, such as Jarvis's adjuster, Bloxham's dislocation tourniquet, etc.; but it has never occurred to me to see any case in which all the force that could be prudently applied to the limb was not easily obtained by the pulleys.

the joint must be maintained by bandages, or slings, for a certain period, which varies for each joint, and which is prescribed for each in subsequent sections. If this precaution is omitted, the head of the bone will almost certainly slip out of the lacerated opening in its articular capsule, and the dislocation be reproduced; or even where this does not take place, the motion of the joint will cause some amount of effusion, which will interfere with the proper union of its ligaments, and leave the joint permanently weak, and very liable to consecutive dislocation. Cases of this kind are very frequently seen, in which dislocation is reproduced by very trifling causes, and is as easily reduced, showing the laxity and weakness of all the parts surrounding the articulation. Hence it is important to keep the parts at rest during a sufficient time, though the opposite extreme must also be avoided, for too protracted inaction might cause troublesome or even permanent loss of motion from soft anchylosis.

When reduction fails from any cause, much judgment and care are required to determine whether the attempt should be renewed or abandoned. On the one hand, the damage and discredit of leaving the patient to his fate will weigh powerfully in favor of perseverance; on the other, serious mischief has often resulted from too protracted and too violent attempts at reduction. Bones have been fractured, tendons ruptured, even the large vessels of a limb have been torn.[1] Still more frequently the pressure of the bandages produces troublesome sloughing, which, when the limb is of small size, as the thumb, may even cause the loss of all its remaining usefulness.[2] The method of procedure which was adopted should be carefully reviewed, in order to see whether there was any fault in it; in which case there will be much encouragement for the trial of a better plan. If, however, no improvement can be suggested in this respect, then attention must be directed to the position of the limb, whether changed or not by the extension; to the nature of the dislocation; the state of the parts; and to the time which has elapsed since the accident. If the position of the displaced bone has been, though not entirely remedied, yet improved; if no injury has been done by the extension; if the dislocation is within a period at which reduction is commonly successful, and of a joint which offers no peculiar obstacles — then the decision will be in favor of persevering; while in the opposite case the surgeon will probably require the expressed wish of his patient (if a person of intelligence and with a full understanding of the question), and the assent of competent colleagues, before venturing on a step which involves certain risk, and offers only doubtful advantage.

If it be found necessary to abandon a case of dislocation, the patient may be comforted with the assurance that his limb, though it will never be as useful as before, may yet recover a good deal of motion; at least, this assurance may be given very confidently in the case of such joints as the hip and shoulder. The ultimate result of such cases is, that the displaced bone forms for itself a new socket, in which a considerable amount of motion is allowed. The result in ginglymoid joints is usually less favorable; still, they may do well if passive motion be kept up.

Partial dislocation.—The previous observations refer to complete dislocations. It remains that something be said about partial dislocation. This injury is rarely met with in the large enarthrodial joints; whether because it really only occurs thus rarely, or whether in part from the difficulty of diagnosis, may be a question; but the rarity of undoubted specimens to be found in our great museums, and still more the rarity of dissections of these injuries soon after the occurrence of the accident, leave little doubt that the lesion is not common. It need hardly be said, at the present day, that the great majority of the specimens which used to be described as "partial dislocation" are really instances of displacement from disease.

The symptoms of partial would be the same as those of complete dislocation, only less strongly marked, viz., sudden loss of motion, change of shape (independent of other concomitant injuries), and change in direction of the axis of the limb. But it will be at once allowed, by any one who has seen much of surgical practice,

[1] A paper by Mr. Callender, in vol. ii. of the St. Bartholomew's Hospital Reports, may be referred to as giving a very interesting account of the cases in which rupture of the axillary vessels has been known to occur in the reduction of a dislocation. This accident is rare, occurs almost always in elderly persons, and has affected the artery in every recorded case except one, in which the vein alone was torn (Price's case, loc. cit., p. 108). [See also Phila. Med. Times, Aug. 16, 1873.]

[2] Samuel Cooper (First Lines of Surgery, 7th ed., p. 705) gives the surgeons of St. George's Hospital, fifty years before his day, the credit of having *pulled off* a man's thumb in vain attempts to reduce a dislocation. I cannot find on what authority this story rests; but gangrene has no doubt often followed such attempts. A case was lately published in France in which the forearm of an old woman was torn off at the elbow in attempting to reduce a dislocation of the shoulder. Gazette Hebd., 1864, p. 299.

how difficult it is to distinguish these symptoms in the case of a deeply-seated joint from the effects of severe contusion or impacted fracture; and hence in such joints the diagnosis must remain rather uncertain. In some articulations, however, such as the knee, where the bones are in contact by very wide surfaces, any dislocation which occurs is almost necessarily partial, and here the diagnosis can generally be easily made.

The treatment must be regulated by general principles, even if the diagnosis remain somewhat doubtful. The limb must be manipulated, under chloroform [or ether] if necessary, until its axis is natural and its length corresponds with the other, and it is, if possible, restored to free passive motion; and it must be then confined to this position for as long a period as may be judged necessary.

The progress of the case will generally afford valuable information as to the presence or absence of fracture; since if the ligaments merely be ruptured, and the bones partially displaced, sufficient solidity is very soon obtained to restore at least some extent of motion; while in fracture the limb continues for a long period quite as helpless as on the first receipt of the injury; for the uniting medium even in the smallest bones does not acquire sufficient solidity to allow of voluntary motion for at least a fortnight; and a much longer period is required in the large bones of the limbs, which are the usual subjects of such an accident as is here spoken of. Ecchymoses also appear, *cæteris paribus*, to be more extensive and persistent in fractures than in other injuries.[1]

Compound dislocation is an accident rarely met with uncomplicated, except in the ankle joint, or some of the articulations of the fingers, as the metacarpo-phalangeal joint of the thumb. Rules for the treatment of each special accident, deduced from experience, will be found in other parts of this work. The general considerations which should guide us in treating these injuries appear to be :—

1. That the injury does not of itself call for amputation, unless perhaps in the knee [or ankle], and here only in adult life.

2. That if the head of the bone protrudes from the wound, it is better to remove it than to make any violent efforts at reduction.

3. That it is always better to excise the end or ends of the bones when the joint is one in which anchylosis is specially to be deprecated.

4. That in the joints of the lower extremity no bone should be removed unless absolutely necessary, and every attempt made, by enforcing strict rest and confined position, to induce anchylosis.

The prognosis of compound dislocations of large joints is highly unfavorable; and in any joint anchylosis will most probably ensue, though in the fingers it may sometimes be obviated by timely passive motion.

[1] Packard's Malgaigne, pp. 84, 418.

PART IV.

COMPLICATIONS OF INJURIES.

ERYSIPELAS.
PYÆMIA.
TETANUS.
DELIRIUM TREMENS.
HYSTERIA.

PART IV.

COMPLICATIONS OF INJURIES.

ERYSIPELAS.

By Campbell De Morgan, F.R.S.

Revised by William Hunt, M.D.

A DIFFUSED, spreading inflammation of the skin, involving more or less deeply the subcutaneous tissues, and preceded and accompanied by febrile action.

The term Erysipelas[1] has been applied to a variety of forms of inflammation which probably have no true connection with one another. On the other hand, distinctions have been made between forms of inflammation which are merely modifications of the same essential disease, erysipelas. The term is now, however, very properly restricted to a spreading inflammation, usually of an atonic character, the result of a peculiar morbid state of the blood.

Of so specific a character is the disease, that in one of its forms at least it has been considered as belonging to the order of contagious exanthemata. It resembles the true exanthemata, in its being sometimes infectious and sometimes epidemic, in its having its period of incubation, and a general tendency to definite duration. It differs from them chiefly in its liability to frequent recurrence.

By Willan it has been placed amongst the vesicular eruptive diseases, from the disposition to the formation of bullæ or vesicles. These, however, are only accidental.

The term erysipelas, according to some, should be restricted to the diffuse inflammation of the head and face. Although this may be taken as the type of true simple erysipelas, the restriction is hardly tenable.

Looking to its causes, the disease may be divided into Symptomatic Erysipelas (*E. consensuale*)—the expression of some pre-existing constitutional disturbance; Idiopathic Erysipelas—the result of general causes acting on the system from without, such as exposure, miasm, or epidemy;[2] and Traumatic Erysipelas—where the inflammation is directly excited by local irritation or inoculation. The classification into symptomatic and idiopathic is not perhaps practically important; that into traumatic is more so, inasmuch as the severe forms of inflammation of the subcutaneous tissues usually follow wounds and other local injuries.

There are two principal varieties which are now universally distinguished: Simple Erysipelas (*E. simplex, verum, legitimum, superficiale, febris erysipelatosa*), the cutaneous erysipelas of Mr. Nunneley, where the inflammation is more or less limited to the skin, the subcutaneous cellular tissue

[1] The derivation of this term has occasioned some discussion: for the following note on the subject I am indebted to Mr. Robson, the printer of the first edition of this work: "There seems to be no difficulty, etymologically, in deriving ἐρυσιπελας from ἐρ·θρός *red*, and πελλα *skin*. The stem of ἐρ·θρός is undoubtedly ἐρ·θ-, Lat. *rub-* in *ruber*, Germ. *roth*, Engl. *rud-* in *ruddy, red*. With regard to the change of the θ into σ in some compounds, Benfey, in his *Griechisches Wurzellexikon*, vol. ii. p. 125. says: 'ἐρ·θίβη rhodisch, wie ἐρ·θίβιος zeigt, in der κοινή σ = θ, in ἐρ·σίβη;' which accounts for the σ instead of θ in ἐρυσίπελας. And for -πελας from πέλλα, Liddell and Scott (*Lexic.* s. v.), compare ἄπελος, to account for the single λ."

[2] The terms "idiopathic" and "symptomatic" are often used in a reversed sense from that given in the text; which is, however, more in accordance with the real meaning of the words, and has been adopted by Sir W. Lawrence and many of the best authorities.

being only slightly or not at all affected; Phlegmonous Erysipelas, or the cellulo-cutaneous of Nunneley (*E. phlegmonodes, pseudo-erysipelas, phlegmon diffus.*), in which the inflammation partakes somewhat of the character of phlegmon, affecting concurrently with the skin the cellular and adipose tissues beneath, and generally running on to suppuration.

There is no real boundary between these two varieties. Simple erysipelas usually involves the cellular tissue to a certain extent, and may even be followed by suppuration in it. Phlegmonous erysipelas will often terminate in resolution. A third variety is perhaps admissible,—Œdematous Erysipelas (*E. œdematodes*); for although œdema is always present, more or less, in this disease, and largely so in situations where the skin is lax, as in the scrotum or eyelids, yet in some states of system the cellular tissue is loaded with serum beyond what would be expected from the amount of cutaneous inflammation, which in these cases often does not present its usual bright color. There is yet one form of inflammation which, although in it the primary affection of the skin is absent, is yet so identical with erysipelas in its causes and in most of its essential characters, that it cannot properly be dissociated from it, namely, diffuse cellular inflammation,—the cellular erysipelas of Nunneley.

These various forms of inflammation and their modifications must be regarded but as phases of one disease, which has its seat not merely in the part, but in the system. The form which the disease may take is determined by the state of system, the temperament, habits, etc., of the individual, or the external causes which produce it.

In adopting this view of the nature of erysipelas, which is supported by its infectious nature, by the occurrence of premonitory fever, and by its definite course, it is desirable to discontinue the application of the term erythema to its milder forms. The latter term has been applied to every form of simple local efflorescence of the skin, whether arising from internal causes or from external irritation merely. It is, perhaps, practically difficult to draw a line between them in all cases, though the real distinction is obvious. Erysipelas presupposes a specific determining cause; but those forms of cutaneous diffuse inflammation which arise from external causes only, as stings, burning by chemical or other means, friction (*intertrigo*), or from the irritation produced by the introduction of indigestible food into the stomach, are in no way allied to it, and may be properly classed under the head of erythema.

Besides diffuse cellular inflammation, there are many diseases which do not produce the characteristic cutaneous inflammation of erysipelas, yet are probably closely allied to it, as *e. g.*, phlebitis both external and internal, inflamed absorbents, and puerperal fever.[1] The same may be said of some forms of inflammation of the mucous and serous membranes. For though the inflammation of the skin be absent, yet if the constitutional conditions be the same, they must be regarded as pathologically identical with erysipelas, however the expression of the condition may differ; just as in syphilis the same virus may produce simple chancre or phagedænic sore, or various forms of cutaneous disease, or deep-seated inflammation.

It has been objected by Sir W. Lawrence, who in this supports the views of Vogel and Hildebrand, that to justify the notion of the mucous or serous membranes being affected by erysipelas, it must be shown that the same phenomena are observable in them as are seen in the skin.

If, however, the view generally received at the present day be correct, that erysipelas is the expression of a peculiar state of system, the result of some poison introduced into or generated in the body, it is no longer necessary to find identity of character in the inflammations of the internal and external surfaces affected by it. Thus no one would deny to the sore throat of scarlet fever a special origin, though often the characters of the inflammation in no way differ from those of a simple non-contagious sore throat. Indeed, the argument of Sir W. Lawrence, founded on the state of the throat, is answered by what is seen in scarlet fever. He observes that the swelling and vesications of erysipelas are not found in the inflammations of the throat attending erysipelas, "which, on the other hand, are frequently attended with ulceration, with the formation of an ash-colored or tawny substance adhering to the surface, and with superficial sloughing—occurrences either very unusual or not belonging at all to erysipelas."[2] Now in scarlet fever the skin-rash never goes beyond a mere efflorescence, with sometimes a slight vesicular eruption. But in the mucous membrane of the throat, ulcerations preceded by ashy or white exudation are common. The sore throat partakes, nevertheless, as much of the specific nature of the disease as the

[1] Velpeau, in his clinical lecture on erysipelas (Lécons orales, vol. iii, p. 235), classes together angeioleucitis, external phlebitis, diffuse phlegmon, and true erysipelas; though he maintains that they are widely different from one another. But he describes diffuse phlegmon as differing from what he considers true erysipelas (*E. légitime*) to as great an extent as angeioleucitis or external phlebitis do from either of them.

[2] Medico-Chirurg. Trans., vol. xiv, p. 22.

rash. And so in those cases where the recession of the inflammation of the skin has been immediately followed by deeper-seated inflammation, there need be no special character to mark the nature of the disease, though the inflammation may really depend on special causes.

Although erythema is regarded as differing from erysipelas in its essential character, yet from a certain similarity between the two, it may be well to give a short description of this affection. Erythema is a pale-red efflorescence invading only the superficial layers of the skin, though sometimes œdema is present, but rather as a cause than an effect of the inflammation. In general it is accompanied by only trifling swelling, which soon subsides. It appears in irregularly circumscribed patches—sometimes there may be but one, oftener there are many—which have not the tendency to spread widely, and join like those of erysipelas; they rarely exceed a few inches in extent, and in some forms are not more than a quarter of an inch in diameter. The patches may appear on any part of the body; their most usual seat is the chest and limbs, and they are generally confined to the part in which they first appear, though this is not invariably the case. The course of the disease is generally rapid, from four or five days to a fortnight in duration; sometimes it is chronic, and it is said even to be intermittent. Usually the eruption is unaccompanied by fever, and in most forms is unattended with pain.

Many varieties of this disease have been described, which seem to have little alliance with one another. Indeed erythema appears to be a symptom common to a variety of states of system and to mere local irritation.

Symptomatic erythema appears in the course of other diseases, or arises from some transient constitutional disturbance, as from errors of diet, teething, or irregular menstruation. It occurs generally in persons of irritable lax habit, with delicate skin. In many persons the slightest causes induce an attack.

Fugacious erythema (*E. fugax*) is frequently associated with other and more serious diseases, especially long-standing disease of the alimentary and other mucous membranes. But there are few internal affections which may not at times be accompanied by it; and it is often an indication both of their presence and their severity. It may come on, however, simply from errors of diet, particular articles of food, as shell-fish, pork, etc., invariably producing it in some individuals. A case occurred to me in which the mere touch of laudanum would bring it on. It appears in the form of variously-sized diffused patches, invading chiefly the upper parts of the body, and occurs most frequently in females. The peculiar character of this variety is its tendency to disappear suddenly at one part, to make its appearance again at another, this being repeated over and over again. There is a little heat, but no pain, and desquamation rarely follows its subsidence.[1]

Erythema circinatum and *marginatum* are degrees of the same form. In *E. circinatum* a number of small round patches appear, which spread at their circumference while they fade in the centre, and by their intersections form a cluster of imperfect rings. Mr. Erasmus Wilson mentions a case in which the curves spread until the whole trunk and limbs had been occupied by them.

E. marginatum differs principally in the deeper congestion of the spots and rings; the color approaches at times to purple, and the borders are more raised and defined. It is more frequently seen in elderly persons, and in connection with disease of the internal organs.

E. papulatum is distinguished by the small size of the patches, which are at first of bright-red color and a little raised; they become ultimately dark-colored. A modification of this variety is *E. tuberculatum*, which is found more usually in debilitated persons, and is often ushered in by chills and fever; the spots are more elevated and persistent than in the papular form.

Erythema nodosum is usually seen in females of weakly and anæmic habit of body, and is not unfrequently associated with rheumatism. It appears in patches of tolerably uniform oval form, and sometimes two or three inches in diameter; the patches are elevated and have a tuberculated feel; they are painful and often very tender. Like the former variety, they are at first bright, but become in the course of a few days dark-colored and livid, and then gradually fade, and are followed by desquamation of the cuticle. The eruption is always preceded by febrile symptoms, sometimes severe, and derangement of the digestive organs; these symptoms disappear as the eruption comes out.

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[1] The erythema often seen in persons who are inhaling chloroform, shows the dependence of these forms of rash on altered states of the vasi-motor nervous system. Dr. J. Murray, who for some time administered chloroform at the Middlesex Hospital, tells me that the rash appears chiefly in the form of small patches about the chest, but is more general about the neck and face. It is often accompanied by evident enlargement of the thyroid gland. It appears previous to complete insensibility, and passes off during or shortly after an ordinary prolonged state of anæsthesia. Dr. Murray says that it occurs in fully five per cent. of the cases of chloroform inhalation.

The treatment of these varieties of symptomatic erythema must be guided by the general condition of system under which they appear. Where they depend on mere casual derangement of the digestive organs, mild saline purgatives and a regulated diet, with the occasional use of the tepid bath, or simple sponging of the skin with tepid water, will be all that is necessary. Tonics are often called for, as generally the disease occurs in persons of weakly habit or who are debilitated by disease.

Idiopathic erythema may be produced by anything which irritates the skin, whether acting from within or without. Thus we have an erythematous state of skin from the distension of œdema in weak persons; *E. læve, œdematosum.* Here the skin has a uniformly shining transparent red appearance; this may continue long, without change, and may then terminate in resolution, or ulceration, or even mortification may take place. A long-continued depending position may produce it; and sometimes a similar inflammation may arise from internal derangement. The treatment consists in rest, position, cold lotions, and then gentle friction and the application of a woven bandage, with, of course, attention to the general state of the system.

E. intertrigo arises from friction of one part of the skin against another, or from the dress, or from the irritation of discharges; it is common in infants and in very fat persons. Chemical irritants, sunburn, alternations of heat and cold, etc., will produce the same effect. Cleanliness, the removal of the cause, and weak lotions of lead, nitrate of silver, or corrosive sublimate, will generally suffice to remove it.

Erythema sometimes presents itself in a chronic form, especially on the face; it is often obstinate, depending on internal derangements, to which the attention must be directed in order to remove the disease. As a general rule, symptomatic erythema springs entirely from causes operating within the system, while erysipelas for the most part implies the concurrence of external and special influences.

We may now proceed with the consideration of the characters of erysipelas.

The inflammation, being the manifestation of some contamination of the fluids of the body, is, as would be expected, preceded by more or less of constitutional disturbance. This is sometimes so slight as to be unnoticed by the patient, and hence it has been supposed that the inflammation may occur without the general symptoms. In many cases where this has been supposed to occur, the skin-affection has been one of simple erythema. The most usual premonitory or accompanying constitutional symptoms are a general feeling of indisposition, languor, and chilliness, amounting at times to severe rigor. The skin is hot and dry; there is loss of appetite and thirst, with præcordial pain; a bitter taste in the mouth, and eructations. The tongue from the first indicates the disorder of the digestive system. It is at first pale and flabby, and then becomes coated with a yellow creamy mucus. In the latter stages it usually becomes dry and brown and fissured, but sometimes it passes at once to brown, though there may have been little or no previous fever, and this is frequently the case where dropsy is present. The bowels are almost always constipated, and, when acted on, the motions are often black and offensive. Occasionally, however, diarrhœa sets in from the first, the motions being offensive, and it is not unusual for relaxation of the bowels to occur towards the close in favorable cases. Where these symptoms of derangement of the digestive system are especially marked, and the countenance assumes a yellow hue, the term "bilious" has been applied to the erysipelas. The state of the urine, which should always be looked to, varies with the intensity of the febrile symptoms; sometimes it is but little altered, often it is high-colored and scanty, depositing abundantly the amorphous lithates. The application of heat will, as in many febrile diseases, often produce a slight cloudiness from coagulated albumen; and in aggravated cases there may be a very considerable amount of it, the result of temporary congestion of the kidney. This is most usually seen towards the termination of the inflammation, where desquamation is taking place, and at this time renal epithelium will often be found as well. But in a large number of cases there is no appearance of albumen in the urine. Dr. Begbie finds that albuminuria is more frequently present in symptomatic than in traumatic erysipelas. The urine is almost always acid, and abounds in urea, but with a diminution of the chlorides. The pulse is quickened; sometimes it is full, soft, and compressible; sometimes, and especially in fatal cases, irregular and intermittent. When the disease has advanced, it may become rapid, small, and weak; but often it remains large till the death of the patient, or the subsidence of the disease. It has been observed by Nunneley, and confirmed by Mr. Hinckes Bird and others, that if the pulse rise in frequency after the sixth or seventh day, it is a very bad sign; this is generally true, though patients will often recover, in whom the quickening of the pulse at this period has been noticed. The blood, drawn during the early stages, generally shows the buffy coat. The blood-corpuscles are diminished in number, according to Andral and Gavarret, and Schönbein says that the serum is always tinged

yellow by the coloring matter of the bile.[1] In erysipelas of the head there is often bleeding from the nose during the acute stage.

The nervous system sometimes shows no further disturbance than the lassitude attendant on febrile action. Often, however, and especially in erysipelas of the head, there is, even in the earlier stages, aching and oppression in the head, drowsiness, or excitement amounting to delirium. In the latter stages of the more formidable cases of the disease, low muttering delirium and subsultus are present. The delirium does not usually at any period present the characters of excitement, but rather the type seen in low fever.[2] Sometimes it resembles delirium tremens, the patient being readily recalled to consciousness when spoken to, but relapsing speedily into a wandering state. The excitement is, however, rarely so great as in delirium tremens. Generally, in the first instance, the wandering or delirium takes place only in the night, the mind during the day being unimpaired.

During the early periods of the disease the temperature rises. The premonitory rigor is attended by an increase of 3° or 4°, and from this time, so long as the inflammation is extending, the temperature will often range from 102° to 105.5°, being generally lower during the middle of the day than in the morning and evening, and lower in the morning than in the evening. Every fresh attack, or more active extension of the inflammation, is marked by an increase of the temperature. Generally the changes in temperature coincide with changes in the pulse, becoming higher as the pulse rises in frequency; but towards the end of the complaint the temperature often falls, while the pulse remains quick. In favorable cases the temperature usually falls to the natural standard on the sixth or seventh day of the eruption.

Frank has pointed out a symptom which he regards as of great value in determining the advent of erysipelas of the head and face. Whenever, he says, the patient has had severe febrile symptoms for some hours, attended with pain, tenderness, and swelling of the lymphatic glands of the neck, he has no hesitation in determining that erysipelas is coming on. Chomel maintains the same view. It is denied by Velpeau, who regards the swelling as consequent upon, not as a precursor to, the inflammation. There is no doubt, however, that the neighboring glands are generally if not always tender before erysipelas of a part sets in. Mr. Busk, indeed, tells me that, after close observation of a large number of cases, he is so convinced of the invariable occurrence of affection of the glands before erysipelas appears, as to consider it a pathognomonic symptom; and he believes that, although the blood becomes affected, the actual primary seat of the local inflammation is in the absorbent system. Sometimes swelling and excessive tenderness of the glands precedes by many hours the appearance of a blush on the skin.

If a wound or granulating surface exist, it takes on an altered action. The edges or surface become flabby, and covered with thin serum instead of healthy pus. Granulations become pale, and are absorbed; parts tending to unite are disunited.

The seizure has been described as having in some cases been extremely sudden and violent. This has been noticed during the prevalence of violent epidemic erysipelas. It is reported of the late Sir George Beaumont, that he was at work after breakfast upon a picture, and fell down in a fainting-fit. Erysipelas presently showed itself on the head, and soon proved fatal.

The severity of the premonitory symptoms is not necessarily an indication of the severity of the erysipelas. They may be very violent, and the inflammation slight, and *vice versâ*. This seems to depend much on the temperament of the individual, and the greater or less tendency to constitutional reaction under partial derangement. The character of the symptoms, too, is modified by the same causes. One person will be restless and excited, another torpid; in one there may be violent rigors, in another scarcely a feeling of chilliness, though the inflammation developed may be the same in situation and intensity. The period that may elapse between the attack of febrile symptoms and the development of the local inflammation, is far from being a fixed one. It may vary from a few hours to three or four days, and in rare cases to even a longer time.

The local symptoms may be described under the principal forms of the disease in which they are developed, viz., of simple and phlegmonous erysipelas, and of diffuse cellular inflammation.

In its mildest form the inflammation resembles in all respects a simple erythema. The skin becomes of a diffused bright-red color; it retains its usual pliancy, and there is no swelling to be either seen or felt, neither is there any vesication. The pa-

[1] Simon's Animal Chemistry, Sydenham Soc. Translation, vol. i. p. 277.

[2] Dr. Bastian brought before the Pathological Society, in January, 1869, some observations on the state of the small arteries and capillaries of the gray matter of the brain in a fatal case of erysipelas of the head with delirium. These vessels were loaded with small aggregated masses of white corpuscles. The same condition was found in the capillaries of the liver and kidneys. To this embolism Dr. Bastian attributes the delirium and the albuminuria found in erysipelas and some other febrile diseases.

tient experiences a sensation of tingling and slight burning in the part. The constitutional symptoms are usually very slight, and the inflammation terminates after a day or two in resolution, followed perhaps by some desquamation of the cuticle. In its severer forms, simple erysipelas presents more definite characters. The skin becomes red, tense, and shining; frequently of a rose tint, whence the popular name; but the color may vary from a reddish-yellow to a deep livid red. The appearance of swelling may be at first very slight, but on passing the hand from the sound to the inflamed surface, a marked elevation of the latter will be noticed. The limits of the inflammation are, in general, sharply defined—the redness not merging insensibly into the natural color of the skin, as is seen in phlegmon. A large portion of the skin may be attacked at once, and the inflammation has a tendency to spread widely in all directions; or in one direction especially; or it may be to break out in new patches, which extend and merge into one another, and into the part primarily affected. The parts newly invaded present the most characteristic appearances, as the disease is usually fading in those first attacked, while it is spreading to parts beyond. The redness disappears on pressure, and returns immediately on the pressure being removed. The skin has a more resisting feel than natural, and is hot to the touch. Very frequently miliary vesicles, or large bullæ, appear after the first few days, which burst and form incrustations; hence the terms *E. miliare* and *phlyctenodes*. The vesicles are usually filled with a transparent serum, changing afterwards to a straw-color and becoming often semipurulent; in weakened states of the system their contents have a deep purple color. The pain is at first of a tingling and itching character, becoming afterwards more severe, burning and smarting. But it is not constant, nor is it ever of the throbbing, wearing kind which exists in ordinary phlegmon. Often there is an almost entire absence of pain; but tenderness on pressure is always present. This is most marked while the inflammation is recent; hence at the circumference there may be great tenderness, while in the central parts it may have disappeared.

The inflammation, though chiefly affecting the skin, is not limited to it. The areolar tissue beneath is more or less infiltrated with serum; so that, soon after the first invasion of the disease, considerable tumefaction takes place, and the skin becomes correspondingly tense and shining. When the face is the seat of the inflammation it becomes enormously swollen, so that the features are altogether obliterated.

Suppuration and gangrene do not generally result from this form of erysipelas; suppuration, however, occasionally takes place in small patches beneath the skin, especially in parts where the cellular tissue is lax; and gangrene may occur in persons whose systems have previously been much debilitated. The more usual course is, that the inflammation extends and retains its activity for three or four days, and then gradually declines, the swelling decreasing from the absorption of the serum, and the skin getting a somewhat shrivelled look and a deeper red color. The whole passes off in from seven to ten days. When the redness and tension persist for a much longer period, a deeper-seated inflammation, with suppuration, may be suspected. Desquamation of the cuticle almost always follows the subsidence of the inflammation.

Simple erysipelas, unless it attack the head and face, or occur in persons already enfeebled by disease, is not of itself a formidable complaint. In the head and face it is dangerous, from the tendency to affection of the deeper-seated organs. Thus the membranes of the brain are often much congested from the pressure made by the swollen tissues of the face and neck on the veins returning blood from the head, the membranes being already in a partially congested state from the febrile condition attending the disease.

Occasionally cerebral excitement like that of delirium tremens takes place, and this even after the early and active state of the erysipelas of the head has subsided. This usually occurs in those who have habitually led irregular lives, and should be looked on perhaps as an accession of delirium tremens upon an attack of erysipelas.

Dr. Copland[1] mentions a case which occurred in the practice of Mr. Byam, and in which the "cellular tissue of the throat and of the whole neck was so distended, that the integuments appeared girt around them with the utmost tension; and in this instance the respiration and cough were as distinctly croupal as in idiopathic croup." Severe inflammation of the membrane of the fauces, with affection of the larynx, is another source of danger. It sometimes gives rise to that most dangerous condition, œdema of the glottis. In one of the cases recorded by Mr. Arnott[2] death ensued from ulceration and sloughing at the back of the larynx. Although erysipelas did not make its appearance externally in this case, yet the fact that two members of the family were seized with sore throat, accompanied by severe erysipelas, justifies the conclusion that this was a case of suppressed erysipelas; of the same nature, pathologically, as the sore throat of suppressed scarlatina.

[1] Dictionary of Medicine, art. "Erysipelas."
[2] Medical and Physical Journal, March, 1827.

The congested state of the lungs, which is occasionally found to exist in these cases, depends no doubt on the impeded respiration, produced by the swollen mucous membranes.

These accidents occur most frequently in phlegmonous erysipelas; but they may take place in the more aggravated forms of the simple variety.

In œdematous erysipelas, the characters of the disease are considerably modified by the condition of the patient. It occurs in those of broken-down constitution, affected perhaps with serious organic disease, or reduced by previous illness. Instead of the usual bright rose-color, the skin often presents a pale brownish or pale yellowish-red color, and there is a strong disposition for it to run into gangrene. When this is imminent the pain is greatly aggravated and the skin assumes a livid dark appearance. The cellular tissue becomes loaded with serum, and the affected part presents much of the character of advanced anasarca. Such cases are serious, not so much from the severity of the erysipelas, as from the low state of the vital powers of those in whom it is usually seen.

One or two forms under which the inflammation at times appears may still be mentioned. The disposition to spread from the point originally invaded is one of the distinctive characters of erysipelas. But this tendency is sometimes so great that the inflammation will spread over considerable parts of the body, while those previously affected have returned to their natural state (*E. ambulans*). In a case recorded by La Motte,[1] the inflammation began in the head and extended down the neck and shoulders, and so continued spreading downwards, the upper part getting well, until no portion of the surface of the body had escaped, even down to the fingers and toes. M. Vidal[2] mentions another instance of rapid extension of the disease over the whole surface of the body. In other cases the inflammation will not spread continuously, but will invade distant parts, subsiding in one spot while it breaks out in another. To this form, which illustrates the alliance between erysipelas and the eruptive exanthemata, the term erratic (*E. erraticum*) has been applied.[3]

The severer forms of erysipelas, such as the phlegmonous and œdematous, are rarely erratic; but this erratic tendency, though generally associated with the simple variety, often indicates organic disease of the secreting organs, or broken-down constitution. It is most frequently seen in connection with erysipelas of the trunk, and is very rarely attended with vesication. The inflammation may appear slight and partake more of the characters of a simple erythema; but this form of the disease is never to be regarded without some apprehension.

The metastatic erysipelas, which has been described by many authors, is probably allied to this erratic form. In these cases the inflammation suddenly recedes from the surface, and some internal organ, the lungs, or stomach, or intestines, are immediately affected.

This occurrence is, however, much more rare than was at one time supposed. A few cases have certainly been recorded which seem to establish its possibility; but it is so uncommon that many of the best observers, with the greatest opportunities, have never met with an instance of it. It is not so unusual to find the serous membranes affected coincidently with the skin, or during the course of the disease, but without any disappearance of the erysipelas.

"Universal erysipelas," as it has been called, that is, where the whole surface of the body is attacked at once, not by spreading, must be extremely rare, if it ever occur. Mr. S. Cooper, in his *Surgical Dictionary*, mentions one such case, which was related to him by Mr. Maul, of Southampton, but the details are not given. Another instance is related by M. Renaudin,[1] but somewhat vaguely. It occurred in a woman fifty years of age. "The entire skin of the trunk and limbs was slightly swollen, and was of an intense erysipelatous red color; the face alone seemed to be less affected." It is possible that this may have been an instance of rapid erratic erysipelas.

The other great variety of erysipelas, the phlegmonous, into which, however, the simple form merges insensibly, is of a far more serious character. Simple erysipelas attacks principally the cutis, and the areolar and adipose tissues are affected only in a secondary and comparatively trifling manner; suppuration may indeed occur, but only in small patches and without death of the structures. But in phlegmonous erysipelas the subcutaneous tissues are involved as largely as the skin, and ex-

[1] See Cooper's Surgical Dictionary, art. "Erysipelas."

[2] Médecine Opératoire, vol. i. p. 147.

[3] In reference to this erratic tendency in erysipelas, Hunter says: "There appear to me two ways of accounting for this: one is, that the whole skin is very susceptible of such action, and readily goes on with it by continued sympathy; and the part having gone through the action, like the small-pox, etc., loses the disposition, and the action ceases. The other is, that the inflammation is such as to contaminate while it spreads; but when it has once acted, it is cured, as above observed." See Hunter's Works, Palmer's edition, vol. iii. p. 315.

[1] Dictionnaire des Sciences Médicales.

tensive suppuration and death of the structures involved is the more frequent termination. As in the inflammation of the skin, so in that of the areolar tissue, there is no tendency to limitation and circumscription by lymph; in this respect there is a striking contrast to true phlegmon. The skin itself, congested by the inflammation, and its nutrition interfered with by the destruction of the areolar tissue which supports and carries its vessels, falls largely into gangrene. The general constitutional symptoms which usher in and accompany the inflammation are more severe. Phlegmonous erysipelas is generally the consequence of wounds penetrating to the cellular tissue. It is in the head and in the extremities that the inflammation is seen in its most severe forms. In the former situation, however, destruction of the skin is not frequent.

The general symptoms are, as has been stated, of the same nature as those seen in connection with the simple erysipelas, but they are usually of more aggravated character. Dupuytren has pointed out that the febrile symptoms, although continued, are often marked by paroxysms and remissions, so that they have even been mistaken for those of intermittent fever. The signs of disorder of the digestive system are generally more prominent in phlegmonous than in simple erysipelas. Sometimes, however, the disease sets in mildly, both locally and generally, and gradually assumes a more serious character.

The inflammation may at first present much the same appearance as in the simple form, and there is often pain in the parts for some hours before the fever manifests itself. Generally, however, the redness is less vivid and has a dusky hue, and the color is not uniform; it is usually deeper at the centre than towards the circumference. The swelling is considerable, and pressure with the finger leaves a pit which does not immediately fill up, nor does the color reappear directly upon the removal of the pressure. After a time the skin becomes so tense and hard that pitting under pressure can no longer be produced; the redness becomes deeper and often assumes a violet hue; small vesications and phlyctænæ are frequently but not always present; the pain is severe, burning, and often pulsating, and the general symptoms are aggravated; the urine is high-colored and thick, its quantity is much diminished, and this amounts at times even to suppression; the tongue is thickly coated and yellow.

At this point, about the fifth or sixth day from the invasion of the inflammation, the symptoms often remain for a time stationary, or there may be a fallacious appearance of amendment. From having been hard and resisting, the skin becomes softer, it yields, and again pits under pressure. There is no sign of fluctuation, and the surgeon may be flattered with the hope that resolution is taking place. But the persistence, and often the aggravation of the general symptoms, and, as not unfrequently happens, a fresh attack of rigor, indicate that so far from there being amendment, this is really the period at which the most serious changes are taking place. The cellular tissue has become the seat of suppuration and death. No fluctuation can be perceived, for the pus or purulent serum, when it first forms, is diffused through the areolæ, or in thin layers, without any circumscribing boundary. In some situations, indeed, where the cellular tissue is abundant, as in the eyelids and face generally, the pus is found of good quality and in circumscribed cavities. Nor is the purulent secretion generally of an unhealthy character before sloughing of the tissue takes place, except in those whose general powers are much reduced, when it will be found to be thin and sanious.

If the disease be left to itself, the pus collects in larger quantities, separating the skin from its cellular membrane, and this from the fascia below, even throughout the entire limb, without forming a prominent swelling as in phlegmon, but burrowing amongst the tissues. The skin, thinned and detached, becomes livid, and ulcerates or sloughs. The phlyctænæ which may have formed burst, and show a dead patch of skin beneath them. The pus which escapes is fetid, and shreds or layers of dead cellular tissue are found floating in it. From time to time large flakes of sloughy membrane, often many inches in length, and soaked in pus, are discharged. The destruction of the skin proceeds, parts which hitherto have retained sensibility and color fall into gangrene, and, in extreme cases, an entire limb may be denuded. Generally, however, in the midst of the loosened skin and sloughy cellular tissue, small bands covered with granulations may be seen connecting the skin with the fascia below. These, as Dupuytren has pointed out, should be carefully preserved; they mark situations in which the vessels and nerves have escaped the general destruction, and they serve as starting-points for reparative action.

In general the destructive action of the inflammation is limited by the fascia; but this is not always the case. Where the disease has been very violent, the fascia, the intermuscular septa, the sheaths of the vessels and of the tendons, and the tendons themselves, may become involved. Even the joints may be penetrated and rapidly destroyed, and the bones may be denuded of their periosteum and become necrosed.

Under these circumstances the limb will probably be permanently disabled, even if preserved; and at the best it will be a very long time before the muscles can again be brought into use.

Up to what may be called the third stage of the erysipelas, that, namely, in which the hard brawny state of the skin has not given way to the soft quaggy condition, resolution may take place under active treatment; rarely, indeed, in the lower extremities, in which there is a strong disposition for the inflammation to run on to suppuration. And when suppuration has occurred, the formidable destruction which has been described may, by treatment, be limited or arrested.

The condition of the cellular tissue may often be seen in all its stages in fatal cases; for as the disease is progressive, some parts will be found in which only the earlier changes have taken place, while in others the destruction is complete. At first the tissue is congested and vascular, and its areolæ contain serum, which is occasionally tinged with blood. The serum becomes thicker, and is replaced by a semifluid, whitish, or often deep yellow matter. This is still lodged in the areolæ, and does not flow from them when cut into. By and by true pus appears, which, though still lodged in the cellules of the tissue, escapes when they are laid open. In the last stages the areolar tissue is found broken down, the pus is diffused in layers, and contains the fragments and shreds of cellular membrane.

The skin, where it has remained untouched by ulceration or mortification, loses after death its red color, and appears shrivelled and brown. Its vascular tissue will be found congested, the veins especially being filled with dark thick blood. Pus and serum will be found in its areolæ; and exudations of a plastic kind, such as exist in carbuncle, may be present. The cuticle readily peels off, and it seems as if a thin layer of serum lay between it and the corium.

The internal organs, in fatal cases of erysipelas, do not present any special characters. Almost always there will be some disease of liver, spleen,[1] or kidneys; often congestion of the mucous surfaces of the stomach and intestines; in short, such appearances as might be expected in persons of broken constitution, especially when it is caused by habitual intemperance. The principal morbid characters are found in the blood. In the early stages of the disease it has much the appearance of ordinary inflammatory blood; the fibrin is abundant, and forms a marked buffy coat, and the white corpuscles are very abundant. But when the disease has passed beyond the active stage and the symptoms of depression have come on, the blood loses the disposition to separate, and forms a thin loose coagulum. Where death has occurred from the disease, the blood is sometimes thin and fluid, sometimes pitchy, often depositing a blackish powder. It stains the inner surface of the heart and great vessels, while the course of the superficial veins is tracked out by transudation. The corpuscles are much altered, broken up, and irregular. There are, then, sufficient indications that, as in typhoid and allied diseases, the blood is the principal seat of diseased action, which manifests itself in death and disintegration of the corpuscles.

A very important fact has, however, been mentioned to me by Mr. Busk, viz., that in all the fatal cases which he examined, the lungs were highly congested, and that on close inspection the smaller pulmonary vessels were always found to contain pus; that, in fact, a minor degree of pyæmia was always present. He has observed the same thing in the small veins of the head where that part has been the seat of erysipelas.

In those rarer cases in which the destruction of the fasciæ and intermuscular cellular tissues has taken place, the muscles of the part are found black and soft. There is no evidence that they partake of the inflammatory action; their disorganization probably depends on the destruction of the tissue which supports their vessels, which themselves are first blocked up and ultimately carried away in the general sloughing.

Associated with erysipelas in its causation and in many of the phenomena attending it, is a form of disease which has attracted attention, in this country especially, under the name of "diffuse cellular inflammation." Although many cases of this disease had been described, its true nature was little recognized until the appearance of Dr. Andrew Duncan's paper in the first volume of the "Edinburgh Medical and Chirurgical Transactions." This form of inflammation, which, it may be stated, in its general characters is identical with the cellulitis of phlegmonous erysipelas, arises from many causes. The cases to which Dr. Duncan drew attention were principally those caused by punctures made in venesection and in dissection; but the inflammation may follow any form of injury or surgical operation, or it may even take place without recognized injury, from the general condition of the patient or of

[1] The morbid states of spleen, so often found in connection with erysipelas, are no doubt most frequently dependent on the altered condition of the blood in the later stages of the inflammation, and not on any pre-existing disease of the organ. The kidneys, too, will often be found congested in cases which present no evidence of previous disease of these organs.

the atmosphere. The disease is seen in its most intense form in those cases in which, as in dissection-wound, a septic poison is directly inoculated. Such cases will be more fully treated of under the head of ANIMAL POISONS. They must, however, be shortly noticed here in illustration of the general pathology of the erysipelatous affections.

The diffuse inflammation of the cellular tissue is very frequently seen in connection with absorbent inflammation and phlebitis, as well as with erysipelas; but it may occur independently of either. It may be supposed that they are in some degree allied in their nature, since they are so often seen to prevail at the same time and under similar circumstances. But there must be some condition of the system which modifies the action and determines the course which the inflammation shall take. After inoculation of the same morbid matter, one may be affected with diffuse cellulitis, another with inflamed absorbents, while on a third nothing will be manifested, perhaps, beyond an irritable state of the punctured part.

The general symptoms, when the disease takes place as a consequence of ordinary injury, are the same as are seen in erysipelas, and run the same course; but the tendency to collapse comes on earlier, and the whole course of the disease is more rapid. In the cellulitis which follows the inoculation of septic matter this is especially the case, and death ensues more distinctly from the general poisoning of the system than from the extent and severity of the local affection. The early symptoms may come on insidiously, or may set in with violence, though even then there is usually a feeling of malaise preceding the attack. Profuse sweating is pretty constantly present. The prostration and excitement of the nervous system are more marked than in erysipelas; there is usually great agitation, and the delirium is often very violent. Pain is not at first referred to the seat of the inflammation, but is felt severely in the limbs, or back, or head, and more especially in the præcordium, and it may move from part to part. Pain in the chest, and hurried embarrassed breathing, are present in those cases where the cellular tissue of the pectoral region is affected, as is so usually the case in dissection- and bleeding-wounds. The pulse is rapid from the first. The symptoms are indeed very like those of pyæmia, to which the disease is closely related.

The course of the inflammation of the cellular tissue is the same in both classes of the disease. But while after ordinary injury it spreads like phlegmonous erysipelas, directly from the original seat of the injury, in cases of poisoned wound it attacks a remote part, between which and the puncture, in very many cases, no direct communication can be traced. In dissection-wound there is often inflammation of the absorbents and of the axillary glands; but this does not appear to be a necessary antecedent; it is often absent, or at any rate unnoticed, and is usually transient when it does occur. The puncture, too, may have entirely healed. The inflammation generally attacks the chest on the side which has received the wound, beginning in the neighborhood of the axilla, and spreading over the back and chest and abdomen down to the ilium, but rarely passing to the opposite side. It may, however, begin on the opposite side; or when it has commenced in the ordinary situation, may break out afresh in distant parts or spread across the chest. Often, too, in the course of the disease, patches of erysipelas, or maculæ like those of typhus, may appear in various parts of the body. The extension of the inflammation to the pleura, mediastinum, or pericardium, is not uncommon.

The difference between phlegmonous erysipelas and diffuse cellular inflammation is, that whereas in the former either the skin and cellular tissue are attacked together and from the same cause, or the affection of the cellular tissue is secondary to that of the skin, in the latter the cellular tissue is primarily involved, and the skin may be free entirely from or only secondarily affected with inflammation. The part is swollen and shining, very painful, and often exquisitely tender; but the pain and tenderness are due to the tense condition of the skin, or to the nerves traversing the areolar tissue being involved in the inflammation, not to any inflammation in the skin itself. The swelling is diffused and uniform, not much elevated, and without a defined border. It is at first elastic and hard, but after a time becomes doughy. Occasionally there is crepitation, from the development of gases in the areolar tissue. These changes indicate that the inflammation has run on to suppuration and sloughing. Although the skin does not participate in the primary inflammation, yet there is often an erythematous blush on it indicative of the disease below. The absence of cutaneous inflammation is most marked in those cases which arise from poisoned wound, followed by distant cellulitis. Where the inflammation follows local injury without inoculation, and spreads from the injured part, the skin is frequently affected. It assumes a pale-brownish, œdematous look, and towards the later stages may become livid, and be the seat of bullæ and vesications, and in some places even of sphacelation. It has been observed in some instances that the skin has been colder than natural; but this is by no means necessarily, nor is it perhaps even usually the case.

Resolution may occur, but it is much

less frequent than in phlegmonous erysipelas. In the less severe cases healthy abscess may form; but almost invariably the suppuration is diffused, and death of the cellular tissue ensues.

The condition of the parts is the same as is seen in the subcutaneous tissue after phlegmonous erysipelas; but there is in general a greater disposition to deep suppuration and destruction of fasciæ, intermuscular aponeuroses, and sheaths of tendons. The deeper-seated layers of cellular tissue may become directly inflamed after injuries or operations. Operations on the sternum or neck are sometimes followed by diffuse inflammation in the mediastinum; and lithotomy, or division of fistula, by inflammation of the pelvic fasciæ or the areolar tissue about the rectum.

The inflammation may extend from affections of the throat in malignant scarlet fever, and may supervene in other parts at the termination of low fevers, especially when complicated with disease of the intestinal mucous membranes.

Death occurs in these cases, and especially after dissection or poisoned wound, more rapidly than from erysipelas. Some have terminated fatally as early as the fourth day from the receipt of the wound, and the eighth day seems to be about the average.

In thus bringing together under one head cases of diffuse cellular inflammation arising from dissection-wound and from ordinary injury or operation, it is not assumed that the poison is the same in both instances. The symptoms are the same, but so are those in snake-bites, where the poison is apparently of a specific nature. But it is not improbable that in all these, including erysipelas, the condition of the fluids of the body is really the same; and that though the morbid matters introduced may differ, they will produce a similar change in the blood. The intensity of the symptoms would depend on the degree of concentration of the poison, and the power of the system to resist its action. Chemico-pathology is more and more tending towards the old doctrine of fermentation, and indicates the rapidity with which albumen in certain states will induce changes in the animal fluids. And we have again abundant evidence of the rapid alteration which may take place in the whole mass of the blood under violent nervous impressions.

Causes.—The question as to the essential cause of erysipelas is still involved in much obscurity. There is now no doubt that the inflammation depends on some morbid state of the system, probably beginning in the blood; which, as in the exanthemata and in typhoid fever, manifests itself in an altered local condition and in a general febrile action. Dr. Robert Williams, who objects to the notion that a morbid poison can be developed in the system, supposes that an erysipelatous virus is always more or less present in the atmosphere, ready to act on those who are capable of receiving it in consequence of a pre-existing unhealthy state. It certainly cannot, like an ordinary inflammation, be produced at will by continued local irritation, however intense or prolonged, while in some the slightest local disturbance will excite it; and in such persons, as was pointed out by Hunter, "every inflammation, wherever it exists, will probably be of this kind." Be this as it may, there is no doubt that certain causes predispose to it; and that when the system is thus predisposed, it may arise apparently spontaneously, or from any local irritation.

The causes of erysipelas and of other similar constitutional disorders are usually divided into "predisposing," and "exciting." This division is not, however, sufficient to meet all the requirements of the case; and it is proposed here to distinguish them into *predisposing*, *exciting*, and *efficient* causes. The distinction between them may be thus illustrated. Two patients are admitted into the wards of a well-ventilated hospital, each having received a similar incised wound. The one is in perfect health, the other is suffering under derangement of the liver or kidneys. Supposing that no special cause of vitiation of the atmosphere is present, the wounds in both cases will heal; the one perhaps by the first intention, the other probably more slowly and with unhealthy action; but in neither will erysipelas be likely to occur. If, however, there be placed between these patients another, suffering under erysipelas, the first will probably still go on well, while the second will be attacked by the disease. Here the previous disease will predispose to the reception of the poison, and the wound will excite its action, while the emanation from the erysipelatous patient will be the efficient cause, without which neither of the two other states will be sufficient to induce the special inflammation. In the healthy subject, although an exciting and an efficient cause be present, the system will have strength enough to resist the influence of the miasm; the predisposing cause is absent.

Although in instances such as the foregoing the distinction between predisposing and efficient causes readily suggests itself, yet from our imperfect knowledge of the essential nature of erysipelas, it is not possible in a large number of cases to discriminate between them. An atmosphere tainted by imperfect ventilation, or by noxious effluvia, may possibly generate the poison, or may merely predispose to its reception.

With this reservation, we may consider bad ventilation, especially where the atmosphere is impregnated with any impure exhalation, as among the most common predisposing causes of erysipelas. Hence the frequency and severity of the disease in hospitals a quarter of a century ago, as compared with the present time. A remarkable instance of the truth of this is furnished by the Middlesex Hospital. Previous to the alteration of the hospital in 1848, the ventilation of the wards, but more especially of the passages leading to them, was extremely deficient, and erysipelas, with its allied diseases, pyæmia and diffuse cellular inflammation, were very common. The wards, for the most part, remain unaltered in size, and the position of the windows is the same, but they are on a better construction. The approaches and passages have, however, undergone a complete alteration, and are now thoroughly ventilated. Erysipelas, from being common, has become extremely rare, not more than ten or twelve cases occurring *in* the hospital in the course of the year, nor does the disease appear disposed to spread when cases are admitted. There are few metropolitan hospitals which cannot afford the same kind of evidence. Yet it does not appear that all kinds of vitiation of the atmosphere, however intense, will predispose to the disease. The houses in the neighborhood of the Thames, for example, during the summers when the emanations from it were most offensive, were not particularly visited by the disease. The Crimean army medical report, affords us another remarkable instance. Low fever abounded in the camp and the hospitals, where numbers of wounded were lying; the wounds took on various forms of unhealthy action, but erysipelas was almost entirely absent. Vitiated and unhealthy states of atmosphere, then, even when conjoined with circumstances which are generally most favorable to the reception of the disease, are not of necessity sufficient to induce its appearance. On the other hand, the atmosphere may be vitiated by causes so slight as to escape observation, and yet be abundantly productive of erysipelas. An instructive example of this was seen in one of the male accident-wards of the Middlesex Hospital a few years ago. It was observed that erysipelas commonly attacked the patients in two beds in particular, while it did not occur in any other patient in the ward or in the hospital generally. The constant repetition of this occurrence led to the conclusion that some special cause of vitiation of the atmosphere was in operation in the neighborhood of these beds, and it appeared probable that the presence of a dust-bin in the area below the window, on each side of which they were placed, must have had to do with the phenomenon. The dust-bin was cleansed and whitewashed, its door was kept closed, and directions were given that the window should not be allowed to remain open. The erysipelas at once disappeared. A couple of years afterwards, the disease was again found to attack the patients in the same beds. It appeared that the precautions had been neglected, the dust-bin had again become foul, and the door had been allowed to remain open. The adoption of the same measures again rendered the beds healthy, and they have since remained so. It may be remarked, that no unpleasant effluvium was detected in the neighborhood of the window, which could lead to the impression that the atmosphere was in any way tainted. Here it cannot be determined whether the impure air merely predisposed the patients to take erysipelas, or whether the actual *materies morbi* was generated. The latter is, perhaps, the more probable view.

Exposure to cold and wet, improper or insufficient diet and habitual intemperance, predispose to the disease, partly by their general debilitating effect, partly by their inducing disease of the abdominal viscera, especially of the liver and kidneys. Indeed, derangement of the digestive and excreting organs, particularly diabetes and Bright's disease, must be ranked as amongst the foremost of the predisposing causes. Women suffering from amenorrhœa or dysmenorrhœa seem to be very liable to be attacked by it. Sometimes erysipelatous inflammation takes place periodically at the menstrual period. M. Costallat saw a woman who, during five menstrual periods, had erysipelas of the foot. The catamenia came on as soon as desquamation began.[1] This had been observed too by Hoffman. Patients recovering from dropsy and from fever are prone to it; but it is remarkable that those suffering from pulmonary disease are not very susceptible to its influence, and according to Dr. R. Williams phthisical patients are rarely affected. Powerful mental emotions, whether temporary or continued, are undoubted predisposing causes; and none more so than protracted anxiety—perhaps from its influence on the digestive organs.

In some persons there seems to be a constitutional predisposition to erysipelas, the slightest causes inducing an attack of the inflammation. On what this state of system depends, is often obscure; it does not appear to be connected with the general health. The same proneness to special infection is seen in the case of many other

[1] Vidal, Médecine Opératoire, vol. i. p. 150.

diseases. It is observed, however, that this proneness to the disease is often connected with the rheumatic and gouty diathesis.

Exciting Causes.—Of the exciting causes the most frequent is local injury. Any kind of wound, even the simplest incised wound, any contusion, or fracture, or sprain, may excite the inflammation; but lacerated wounds of the extremities, and scalp-wounds, are its most fruitful sources. Fatal erysipelas has followed the mere removal of an atheromatous tumor of the scalp. But while the inflammation may follow the simplest wounds where every proper attention is paid to them, they become far more decided causes of it if irritated by improper applications or by friction, or if thorough cleanliness be not observed. The retention of an unhealthy purulent discharge by compression or bandages is a common cause of erysipelas.

That erysipelas should follow an ordinary clean incision, without inoculation of a morbid material, and which yet would not have occurred unless some local injury had been inflicted, in no way supports the view that it is a mere modification of an ordinary inflammation. The same thing is seen in other diseases; in gout, for example, where an injury to a joint, or a contusion, or overexertion, will often determine at once an attack in the part.

A current of cold air will excite the disease in the head; and it often follows the application of cold to the loins during menstruation, whereby the discharge is checked. A sudden chill will cause it. Overexertion will determine its appearance. Generally, however, in such cases there are coexisting circumstances favorable to the production of erysipelas; as long exposure to cold or wet, insufficient food, etc. This is often seen in the London hospitals in those who have walked from long distances in search of employment. But there is another and perhaps more decided cause in operation, namely, the vitiation of the blood itself by overexertion. The observations of Duhamel, Haller, and Chaussier show that in overdriven animals the blood becomes disorganized and capable of producing gangrenous pustules and malignant fever when inoculated in healthy animals or in man.[1] And yet, as is seen from the Crimean army report, the fatigue to which the men were exposed, even when followed by severe wounds and confinement in hospital, did not give rise to erysipelas.

The scarification of parts affected with œdema, the legs and scrotum especially, is very apt to excite the disease, as are leechbites and wounds made in venesection; and, when the predisposition is strong, even casual errors of diet. It is frequently seen in hospitals that patients who have received an injury which is going on favorably will be seized with sickness and shivering, and erysipelas will show itself. It will turn out that the mistaken kindness of friends has led them a day or two before to smuggle in some improper food, half-ripe fruit, or pastry. In short, it would seem that anything which produces a sudden derangement of the actions of a part, or of the whole system, may, under certain circumstances, determine an attack of erysipelas. In general, however, in order to induce phlegmonous erysipelas or diffuse cellular inflammation, the exciting cause must operate directly on the areolar tissue.

Efficient Causes.—The efficient causes may be considered under the heads of (1) general atmospheric condition, or epidemy; and (2) infection or contagion.

(1) It is a matter of common observation, that erysipelas is far more prevalent at one time than at another, and in one situation than in another. But this tendency has often been present to so great an extent as to give to the disease the character of a severe epidemic. So far back as the time of Hippocrates this fact was observed. He has described an epidemic erysipelas, commencing in the spring and prolonged through the summer and autumn. In more recent times the records of such invasions have been very numerous. It does not appear that there is any one state of atmosphere in particular which tends to produce these epidemic forms. In some instances the season was cold and damp; in many others great heat and drought prevailed. Winter and summer have alike seen them. Generally, however, other epidemics were prevalent at the same time; and we may hence conclude that the atmosphere was unfitted to destroy the miasmata which were generated.

(2) While the existence of epidemic erysipelas is unquestioned, the infectious nature of the disease is by no means universally admitted. The French writers generally are opposed to such a notion, while it is received by most English authorities. The question is one of great practical importance. The possibility of producing the disease by direct inoculation from the vesicle may be put aside, resting as it does on the unconfirmed experiment of Willan. All hospital surgeons, however, are aware of the risk attending the indiscriminate use of sponges when erysipelas is present in a ward. It is seen that if a wound be cleansed with a sponge which has been used on an erysipelatous patient, the disease is pretty sure to appear in it. In many hospitals sponges are not, on this account, allowed to be used, and tow or

[1] See on this subject Copland's Dictionary, art. "Blood," p. 192.

cotton-wool are substituted, and are at once thrown away. [The use of Morton's carriage, or of some similar contrivance, is one of the best ways to avoid carrying septic material from one patient to another, besides being a great convenience. The water (carbolized or not) is carried from the small tank through a hose from which the wound is washed; thus the same water flows over the wound but once. The waste is caught in a basin and thrown into a receiver on the carriage.][1] And this is a wise precaution. There is, indeed, no proof here that a specific virus is transferred from one patient to another. Those who deny the contagious nature of erysipelas not unreasonably assume that when the disease is prevalent it may be excited by an irritation, and especially by the application of impure animal matter to a wounded or ulcerating surface. In the same way, the mere fact of the extension of erysipelas in a hospital, or other limited locality, without direct contact, is no evidence *per se* of infection. It may, and perhaps most frequently does, depend on peculiar atmospheric conditions, the result of imperfect ventilation or unwholesome exhalations, which generate possibly the efficient, possibly only the predisposing, causes of the disease. It must be admitted that the disposition to the propagation of erysipelas by infection is not so great as is seen in the case of many diseases. But take the instances of scarlet fever, typhus, and typhoid fevers. Of the infectious character of the first no one entertains a doubt. Of that of the two others the evidence is incontrovertible, though it is denied by some; but typhoid, though contagious, is infinitely less so than typhus. In erysipelas this character may be still less marked; but its existence rests on observations too striking and numerous to be set aside without the adoption of explanations far more difficult to receive than the simple one which the facts themselves suggest. And if it can be shown that, in many cases, the evidence of infection is just as strong, and rests on precisely the same grounds as in scarlet fever or typhus, it would surely be irrational to reject that evidence because it militates against a preconceived opinion, or to assign to accidental coincidence sequences of events often recurring and in a regular order.

The cases recorded by Dr. Wells,[2] Dr. Stevenson,[3] Mr. Arnott,[4] Sir W. Lawrence,[1] Dr. Elliotson, Mr. Erichsen,[2] and others, are too well known to require repetition here. They are too numerous and too striking to admit of any reasonable interpretation save that of the presence of disease of an infectious nature. Still it may be useful to put on record new and authentic instances; such as, amongst many others which have come to my knowledge, the two following. The first, which was under the observation of Dr. Rogers of Dean Street, resembles, save in its final termination, the case which Dr. Elliotson has mentioned as having occurred to himself. "A medical student went into the country, and was requested by his brother, a medical man, to visit an erysipelatous patient. Whilst leaning over her, he became conscious of a nauseous odor, which almost caused him to be sick. A few days after he was suddenly seized with shivering, followed by fever; erysipelas shortly came on in the head and face, and he died after a week's illness."

In the second instance, which has been communicated to me by Dr. Goodfellow, as having been witnessed in the Fever Hospital, there seems every reason to think that the disease spread from bed to bed by infection. "In the epidemic of typhus that prevailed in the autumn of 1838, more or less of erysipelas was constantly to be found in the wards; and, as a general rule, it spread from bed to bed. On one occasion, however, this was more than usually striking. It occurred in the large fever-ward, containing thirteen beds, and well ventilated. Erysipelas attacked a patient on that side on which were seven beds. She was in the bed next but one to the end; the patient lying in the next bed, the third from the end, was next attacked, and then the patient at the end. The disease successively attacked all the patients in the order in which the beds were placed until it reached the lower end of the ward. It then attacked the patient lying at the same end of the ward, but on the opposite side, and spread from bed to bed until it reached the last on this side, the patient lying in which was the only one who escaped."

[Whatever may be the varying opinions as to the contagious nature of erysipelas, the question is often practically disregarded as to hospitals. The Pennsylvania Hospital, for example, has a rule that contagious diseases shall not be admitted. Yet erysipelas patients are freely taken in from the receiving rooms. This course would appear to be justified by results, for of sixty-five cases recorded as occurring within five years, *sixty-two* were admitted for the dis-

[1] For full description see Surgery in the Pennsylvania Hospital, Philadelphia, 1880, p. 345.

[2] Trans. of a Society for the Improvement of Med. and Chir. Knowledge, vol. ii.

[3] Trans. of the Medical and Chirurgical Soc. of Edinburgh, vol. ii.

[4] London Medical and Physical Journal, March, 1827.

[1] Medico-Chirurgical Trans., vol. xiv.

[2] Art and Science of Surgery, 5th edition, vol. i. p. 495.

ease. The three others took the disease in the hospital, but there is no evidence of their having had anything to do with each other. Most of the cases were admitted to the medical wards for the simple form of the disease, but some very severe ones were taken into the surgical wards.

We think this record utterly fails to confirm any high degree of contagion, and also if the disease is one of those dependent upon the propagation of spores, that for some reason or another these spores did not act, as no special means were taken to destroy them. "These remarks are made as statements of absolute facts, and are in no way to be used in support of any carelessness or want of precaution as to patients with erysipelas. On the other hand, the record might be quoted as showing the good effects of care and cleanliness in the handling and treatment of such cases. Any attendant who would neglect to wash his hands, after dressing one of these patients, would be guilty of a great wrong. We are almost as much in the dark as ever as to the true nature of contagion, and until we are more enlightened we must adopt empirical measures to prevent it. Erysipelas, we all know, sometimes fairly sweeps through a hospital and then suddenly disappears, leaving for a while no cases at all, and then a few gradually appear. It may be that seasons of exemption are passed through to be followed by those of liability, and if this is the case, and the germ theory applies to this disease, then there must be times when the germs are stillborn or quiescent."[1]]

But the question of the identity in nature of erysipelas proper with many internal inflammations, which has been before alluded to, is one of even greater importance. At the present day, little doubt is entertained by British surgeons of the connection, if not the identity, of this disease with puerperal fever. They both arise under the same circumstances, and the instances of their coexistence in the same patient, and of the tendency which each seems to possess to excite the other, are so numerous, that it is next to impossible to resist the conclusion that puerperal fever is but an internal manifestation of erysipelas. And if so, the entire difficulty of receiving the view that other internal membranes may be the seats of the disease, is removed. That they are far less frequently so than the peritoneum after childbirth, is only what we should expect. They can rarely be exposed to influences so favorable to the production of the disease. Cases such as the following, reported by Dr. Gibson,[1] tend to this conclusion: "An infant was attacked with erysipelas of one foot. The mother was soon afterwards seized with the disease in the head and face. The wet-nurse of the infant was taken with pneumonia, and was removed home, a distance of four miles. Her father, who had had an injury to the head, was soon afterwards seized with erysipelas of the scalp, and died; her sister had low fever, with sore throat; and two children in the same house were attacked with croup, and died." Dr. Warren[2] states broadly, "I have seen numbers of patients perish a few days after operations, at the time that erysipelas prevailed in the hospital, without the slightest external erythema. In such instances I have been in the habit of stating to you that these patients died of erysipelas as truly as if they had been covered with an erythematous eruption." Careful observation is still required on this point, the importance of which in regard to treatment can hardly be overestimated.

DIAGNOSIS.—Erysipelas is little likely to be mistaken for any other disease. Its limitation to one part of the body, and the uniform character of the redness and absence of punctuation where it is invading fresh portions of the skin, and the absence (save in erysipelas of the head and face) of sore throat, distinguish it from scarlet fever. The first of Mr. Arnott's cases recorded in the Medical and Physical Journal might possibly, had it stood alone, have been mistaken for scarlatina maligna. In its severer forms, where there is œdema of the subcutaneous tissue, there is no sort of similarity between them.

Erythema has a greater disposition to appear in patches; there is no swelling, and the general symptoms are usually milder. There is no doubt, however, that under the name of erythema are often included cases of mild erysipelas. It could hardly be mistaken for pemphigus, or any other true vesicular disease. From phlegmon, the whole character of the inflammation and of the pain, its spreading character and the absence of prominent local swelling, the fever which ushers it in, and the absence of limitation, readily distinguish it. M. Vidal mentions a case in which malignant pustule was mistaken for erysipelas: this complaint, however, is little known in England.

Diffuse cellular inflammation is not always so readily distinguished from other diseases. It most resembles those with which it is most frequently associated, such as ordinary internal phlebitis, phlegmasia dolens, or inflamed absorbents. Where, as in a limb, the hard and tender veins can be traced,

[1] See "Surgery in Pennsylvania Hospital," Philadelphia, 1880.

[1] Trans. of Edinb. Med. and Chir. Soc., vol. iii.
[2] On Tumors, p. 255.

and the swelling is principally limited to their track, the distinction may be readily made; but when there is more diffused swelling, and the course of the veins cannot be traced, there may be at first some difficulty. In phlebitis, however, there is much less tendency to discoloration of the skin than even in cellulitis. The appearance of the limb and the early symptoms in intense absorbent inflammation sometimes resemble what is found in diffuse inflammation, and the two frequently coexist; but the red streaks and the extreme tenderness of the glands will point out the presence of the former. Extensive subfascial phlegmonous inflammation may produce rapid and general swelling of a limb, but the swelling soon becomes more localized and elevated; and the character of the pain and the attendant fever are unlike those of diffuse cellulitis.

Prognosis.—So many attendant circumstances must be taken into account in estimating the probable results of an attack of erysipelas, that it is difficult to lay down any general rules for the guidance of the judgment. Each case will present its own special character.

The season, and the general or local state of the atmosphere; the age and constitution of the patient, his previous habits and the coexisting diseases; the exciting cause and mode of invasion, and the character and the situation of the inflammation, must be taken into account. The simple varieties uncomplicated with other disease will, if the patient be placed in a good atmosphere, run their course favorably, and terminate in resolution in from six to ten days. But under other circumstances they may pass into more serious forms, or may of themselves be not unattended with danger. When the disease is epidemic, or endemic, no attack, however slight at first, is quite free from peril; and if at such times it supervene on wounds, the mortality is often great. In the very young and in the aged it is never without danger, nor in persons of cachectic habit, or whose constitution has been broken by previous disease or intemperance. When the disease attacks a dropsical limb, or comes on in the course of a dynamic fever, it often proves fatal. In the former case, this depends rather on the cause of the dropsy than on the local condition; for there are no circumstances under which erysipelas is more dangerous than when the liver or kidneys are diseased. In a large majority of fatal cases in adults, when the erysipelas is not epidemic, it will be found that there is cirrhosis, or some other organic disease of the liver, or degeneration of the kidney. The presence of albumen in the urine, therefore, in the early stages of the disease, and in unvarying amount, must always excite grave apprehension, as must its presence at any period when accompanied by a low specific gravity. In the desquamative stage, as has been stated, albumen is often present in greater or less quantity, but disappears as the disease declines. When diabetes is present, the erysipelas is serious, and often fatal; and when the disease is erratic, or recurrent, or when it lingers on beyond the ordinary periods of resolution—the pulse, instead of becoming slower, remaining quick, or becoming accelerated—a very guarded opinion should be given; such forms are frequently associated with internal organic mischief. It is principally in the two former varieties that metastasis to deepseated parts is said to occur. This is, however, not a common event in any form of erysipelas; when it does take place, it is often fatal.

The more severe forms of the disease, phlegmonous erysipelas and diffuse cellular inflammation, usually occur after wounds; especially lacerated wounds, and those made in the great surgical operations. They are never unattended by danger, but the amount of danger will depend on the presence or absence of the conditions which have been just noticed. It is in the head and in the limbs that injuries most tend to excite the inflammation. In the head it is more specially liable to occur, both symptomatically and idiopathically, and should never be regarded otherwise than as a serious disease, from the disposition which exists to congestion of the membranes of the brain, and to spreading inflammation in the fauces and air-passages. Apart from this, the danger of these forms of erysipelas will be, *cæteris paribus*, in proportion rather to the extent to which the areolar tissue is involved than to the severity of the inflammation; the affection of a whole limb will be more dangerous than a more limited though more intense inflammation. After all, it may be stated as a general proposition, that erysipelas is dangerous more from its association with other diseases than of itself.

While erysipelas is sometimes a serious disease, it not unfrequently has a salutary effect on a part or on the system. It often seems, like a fit of the gout, to clear away a long-standing condition of general indisposition. When the disease has passed off, the patient will be found to have regained elasticity of mind and body. And in the same way, when a part long affected with some chronic intractable disorder has been attacked, the disease will have often disappeared or have been much ameliorated on the subsidence of the inflammation.

Treatment.—From the earliest times to the present day there have prevailed amongst practitioners two entirely opposite views with regard to the treatment of this

disease in its earlier stages. According to the one, the disease, being essentially inflammatory in its character, should be treated according to the general rules laid down for the treatment of inflammation, by free bleeding and other antiphlogistic remedies. According to the other, the inflammation being the result of a lowered state of the system, a supporting and stimulating plan of treatment should at once be had recourse to. Each of these views has found among its supporters men of the highest authority and of the most extended experience. At the present day, indeed, the question no longer possesses the same interest as formerly attached to it. In this country, at least, extensive bleeding has in all cases fallen greatly into disuse; and in erysipelas especially, unless in very exceptional cases, is generally abandoned, though in France it has still its advocates. In investigating the records of this disease, one fact appears to be established,—that whatever plan of treatment was formerly adopted, the inflammation ran a certain course with greater or less severity. What Sir T. Watson says of erysipelas of the head and face is applicable, so far as the treatment by any of the plans formerly recommended is concerned, to all forms of the complaint: "I think the more you see of this disease, the more convinced you will be that it is not to be cut short by any particular mode of treatment; that it will run a certain course." And Velpeau and many others have expressed the same opinion.

Although, undoubtedly, the most satisfactory results have on the whole attended the treatment by support and stimulants, yet it can hardly be denied that the success of the opposite mode, even when carried to an extent which would now be considered by practitioners in this country as highly improper and dangerous, has been such as to render intelligible, if not to justify, its adoption by those who still employ it. Some even of those who advocated a stimulating treatment, condemned the opposite plan only because the convalescence was thereby protracted; and the experience of Larrey has led him to conclude that it is safer in severe cases to treat on either plan than to leave the disease to run its own course. And it is not altogether correct to call erysipelas, as is often done, a disease of debility, in the sense that all who are attacked by it are in a weakened or low state. That the disease, by its continuance, induces such a condition is undoubtedly true; but persons whose general powers are unimpaired may, from occasional and accidental causes, be placed in circumstances under which they may take the disease. In such cases the symptoms would run high, and the question might reasonably be entertained, whether a treatment calculated to diminish the intensity of the symptoms, and ward off the consequences which would follow their free development, would not be justifiable and even appropriate. From improved sanitary conditions, the efficient causes of erysipelas are not now so rife in this country as they formerly were, and those attacked by it are generally, by habitual intemperance or by some continued predisposing cause, very susceptible to its influence; their system is already below par. On the other hand, whatever may be at first the character of the symptoms, the disease sooner or later induces a state of system which demands support; and a wise forethought would lead to the practice of husbanding the patient's strength as far as possible. It is admitted, moreover, on all sides, that cases frequently arise in which depletion could not be thought of, and in which stimulants and support are required from the first; and such are the cases which now almost universally present themselves. There is one circumstance which should never be absent from the mind in considering the propriety of lowering the patient, and that is, the tendency which is often shown to sudden prostration.

Whatever may be the mode of treatment adopted, there is one point which should never be neglected. Every means should be taken to ventilate the room properly; the bed-curtains should be removed, and the air should be freely admitted around the bed. If two or more be affected in the same house or ward of a hospital, they should be separated. These precautions should be taken, not only for the patient's sake, but to prevent as far as possible the risk of infection. If the erysipelas be in the head and face, of course it will be undesirable to allow a draught of air to fall on the patient; but it is equally, or even more important, that the air should not be stagnant about him. When many are attacked in a ward, it is always well to empty it as soon as possible, to have the walls and ceilings washed, and to ventilate it thoroughly.

It is hardly necessary in a treatise like the present, to enter at large upon the various means of internal treatment which have been applied to this disease. The general principles of therapeutics, as applicable either to simple inflammation or to common or specific fevers, have of course been brought to bear upon it. It is clear that, apart from the question of the possibility of attacking the specific cause, no general rule can be laid down which shall apply to a disease which sometimes creates merely a transient febrile condition, at others sets in with a violence almost equal to that of the plague; which is at one time accompanied by high action, at another prostrates

at once the vital powers. Each case must be treated to a certain extent according to the condition of the patient and the character of the attack.

There are certain indications which should never be neglected. It has been seen that the bowels are generally torpid, though sometimes diarrhœa takes place. In either case the evacuations are unhealthy. When there is constipation, and the bowels have been acted on by purgatives, the motions are usually pitchy and very offensive. When diarrhœa is present, the motions, though fluid, have otherwise much the same character, and are dark-colored and offensive. In order to give full effect to any treatment, it is well that these states should be corrected; and few cases occur in which the action of mercury in the first instance is not beneficial. In the more usual torpid states of the bowels, brisk purgation with calomel and jalap or scammony, followed up if necessary by a warm aperient draught, so that natural bilious motions may be obtained, will seldom fail to improve the state of the patient, and will always allow wine and tonics to be given with greater advantage. Even in more advanced cases, when the patient is in a state of prostration, with a dry tongue and weak pulse, if this point has not been previously attended to, his condition will be often found to improve under the action of the medicine, though of course wine and support should be given at the same time; and where the disease sets in with diarrhœa, gray powder with soda three times a day will generally be found beneficial. The same medicine may be advantageously given when, after the bowels have been acted on by calomel, the motions still retain an unhealthy character. In the minor cases, saline medicines, with small doses of sulphate of magnesia, and in some very slight ones mere attention to diet, will be all that is needed. The condition of the bowels is disregarded by some surgeons; and in many cases no doubt the disease will run its course, and the patient recover, where no attention is paid to this point. But it certainly seems consistent with reason, as I believe it is with experience, that the condition which is amongst the most frequent in predisposing to the disease, should as far as possible be removed. Many cases will of course occur in which the judgment of the practitioner will lead him to be more cautious in the use of calomel. Where the erysipelas, for example, appears at the termination of, or associated with, other diseases, such as fever, or dropsy with organic affection of the liver or kidney, active purgation will not be well borne; but even in such cases the use of the milder mercurial preparations will often be advantageous, while support and wine are allowed at the same time. When the derangement of the digestive system has been, as far as may be, removed, quinine, or cinchona, or calumba, will be found useful, though before they may have had the effect of making the patient more feverish.

With the exception perhaps of the tincture of the sesquichloride of iron, our chief trust should be in port wine or spirits and beef-tea. The quantity of wine which it may be desirable to allow must depend very much on the previous habit of the patient as well as on the character of the symptoms. Generally about six ounces a day, if this treatment has been commenced early, will suffice; but in those habituated to free living, or when the supporting plan has not been resorted to until the symptoms of depression have come on, much more will be required. The effects of stimulants must be carefully watched. When they are found to produce dryness, and heat of skin, with increase of restlessness or torpor, it is a sign that they have been carried further than is good, and a longer interval should elapse before they are repeated.

With regard to nourishment, a pint or two of beef-tea, and one or two cups of arrowroot or sago, will in general be all that is required. The stomach is not in a state to digest much, and care should be taken not to overload it. The sensations of the patient are valuable guides. If there be a loathing of food or a tendency to sickness, it is of no use, and will often do much harm, to force nourishment upon him. Wine rarely disagrees, and is as rarely objected to.

Towards the later stages of the disease, if the patient be found in a state of low wandering, with a weak quick pulse, a rough dry tongue, and a cold skin, good bottled stout will be often the best medicine. Patients will be often seen to drink a tumbler or two of it with eagerness, when they have objected to other things, and then to fall into a tranquil sleep; the skin will become warm, and bedewed with a comfortable moisture, and the symptoms on their awakening will be all ameliorated. Instead of wine or stout, it may be often better, in any stage, to give the stimulant to which the patient has been accustomed, especially if he show any marked preference for it.

It is not a little remarkable that, among the numerous medicines which have been tried in erysipelas, that class alone which seems to exercise any really controlling power over the disease should not have had a recognized place till within the last few years, viz., the preparations of iron. This is the more remarkable because Velpeau, so far back as the year 1841, emphatically

pointed out the advantage to be derived from their external use in simple erysipelas (*E. légitime*). In his Leçons Orales, speaking of the failure of other remedies, he says that he was led to try the sulphate of iron, and adds: "It modifies, it changes very positively the erysipelatous inflammation. I do not say that it extinguishes it as soon as it is in contact with it; but it is certain that it sensibly shortens its duration, and that an erysipelatous patch does not resist the application of the sulphate of iron for more than two or three days. Treated by this remedy, an ordinary erysipelas, where there is a succession of patches of inflammation, never lasts more than three to six days, whereas the average duration of the disease is not less than twelve days."[1]

The internal use of iron, in the form of the muriated tincture, had, however, been largely and successfully tried by Dr. G. Hamilton Bell for many years before this date; but it was not until 1851 that the results of his experience were made public in a paper read before the Medico-Chirurgical Society of Edinburgh. The remedy is now in general use, and daily experience shows that its value has hardly been overrated by Dr. Bell. The rationale of its action advanced by Dr. Bell is more questionable. He believes that the beneficial influence of the medicine is due to its controlling power over the tonicity of the capillaries of the inflamed part. That it is useful as a general tonic is very probable; but its peculiar action on the disease, controlling and rapidly cutting it short in a manner effected by no other tonic, seems to indicate that it strikes more at the root of the disease itself, and that its principal effect is on the blood, as was suggested by Velpeau. The opinion given by Dr. Balfour is pretty generally borne out by the experience of those who have given the medicine a fair trial, "that we now possess a certain and unfailing remedy, whether the erysipelas be infantile or adult, idiopathic or traumatic."[2]

Cases may occur now and then in which the iron will appear to be inert. Indeed, I have met with some cases in which, although to all appearance very favorable for the use of the iron, it has had no marked effect in controlling the disease, which has run its usual course. It has appeared to me, nevertheless, that in some of these the constitutional symptoms bore no proportion to the severity of the inflammation. But that given in full doses it will do, in the majority of cases, what no medicine of any other class has yet been found to do, namely, cut short the disease, no one, I believe, who has fairly tried it will deny. Less than a drachm and a half to two drachms a day will rarely in adults produce much effect. In severe cases, an ounce and a half to two ounces a day will often be required. The evidence of its effects rests on this: treated in the ordinary way, erysipelas, as a rule, runs a course of from seven to ten days at the least; treated by the iron, it often subsides in from the second to the fourth day. It should, however, be given cautiously so long as the secretions of the liver and bowels are in the unhealthy state which almost always accompanies the early stages of erysipelas. In such cases the free administration of calomel, followed by warm saline purgatives, is especially called for; nor need the advanced state of the disease, nor the lowness of the patient, interfere with this treatment, if it have not been previously adopted. Even when increased cerebral excitement attends the administration of the medicine, there is no need to discontinue its use, for it will be found that in general the disturbance will subside after a short time, as was pointed out by Dr. Bell. The quantity of the tincture which may be required will depend on the severity of the symptoms. In advanced and serious cases, as much as half a drachm may be given every hour; in slighter ones, fifteen to twenty minims every four hours will suffice.

Of the symptoms which arise in the course of an attack of erysipelas, those which belong to affections of the nervous system are among the most important. They may proceed from vascular excitement, amounting to inflammation of the membranes of the brain, or from congestion, or from the circulation of an impure blood, or from exhaustion of the nervous system. Inflammation is rarely present, unless as a consequence of severe erysipelas of the head. But it must be regarded as itself of an erysipelatous nature, and its treatment must therefore be based on the same general principles as apply to the treatment of erysipelas. It is here, if anywhere, that bleeding may be properly resorted to. The tendency to effusion makes it highly important to lessen as early as possible the vascular action. Should it be thought necessary to take blood, it should be done early, and once for all. But it should be done cautiously, by leeches to the temples, or by small incisions into the inflamed pericranium; and the bleeding should be arrested as soon as an effect has been produced on the pulse. It is only in the young and plethoric, however, and very rarely among the patients in a London hospital, that bleeding is called for. Free purgation, and the use of turpentine enemata, will be in most cases useful. And

[1] Op. cit., p. 307.
[2] Monthly Journal, 1853

when the liver and bowels have been largely unloaded, the iron may be safely given, and will act as in other states of the disease. Wine, too, may be allowed, but its effects must be very carefully watched. When coma has come on after marked inflammatory symptoms, with a rapid pulse and thickly-coated, black, dry tongue, the case is one of the most serious character. Dr. Copland says that he has seen the most marked benefit from the use of calomel, in a full dose, with camphor, followed by turpentine and castor-oil in the form of an electuary, to be placed on the back of the tongue, and repeated until the bowels begin to act, when its operation may be promoted by enemata, blisters being applied to the nape of the neck or inside of the thighs. Copious offensive black motions are generally brought away, with marked amelioration of the symptoms. This mode of treatment, followed by the free use of the tincture of iron and of wine, will, I believe, be effective in apparently hopeless cases.

In the other forms of affection of the nervous system bleeding is never admissible. The general treatment which has been recommended will, in most cases, be all that is required to allay the nervous symptoms. Sometimes, however, they demand special attention. For example, we not unfrequently see cases in which the nervous excitement and restless wakefulness are greatly in excess of the general symptoms of the erysipelas, and tend to exhaust the patient. This has been observed often in connection with erratic, and it is said with metastatic, erysipelas. In such cases morphia or henbane are often of great use; but they should be given very cautiously if there be evidence of the existence of organic disease of the liver or kidneys. As a general rule, indeed, narcotics are not well borne in erysipelas, and tend to cause a dry tongue and congestion of the brain. Under no circumstances should they be given until the bowels have been freely relieved. Camphor, on the other hand, whether wandering or torpor be present, seems to act favorably; and may be freely given when nervous symptoms, and especially those which occur in the later stages of the disease, are marked. Another and a valuable remedy is ammonia. The cases to which it seems most appropriate are those also in which nervous prostration or excitement is especially prominent; where, for example, the inflammation being of the simple kind, the skin remains soft and not burning, or is perhaps cold; where the tongue is moist and flabby, and the pulse quick, large, and weak, while there is great restlessness, or transient delirium, or nervous prostration. But where the tongue is hard, and dry, and fissured, and the skin is hot and dry, ammonia does not appear to me to agree so well.

With regard to the general treatment of diffuse cellular inflammation arising from injury or operation, with or without the inoculation of a morbid poison, there is now little difference amongst surgeons. On all hands the depleting treatment is condemned, and the free and early use of tonics and stimulants recommended. Our chief dependence must be on wine, spirits, or stout, with camphor and henbane, or perhaps opium, to allay the irritable condition of the nervous system and diminish the pain. It may be presumed that the iron remedy will act favorably in such cases, as they are in their nature the same as erysipelas. I have not, however, had any personal experience of its effects.

The local treatment of simple erysipelas and of the early periods of phlegmonous erysipelas must be considered with reference to its effect on the local inflammation and on the disease generally. The suggestion of Hunter, that the inflammation contaminates while it spreads, is one which has perhaps not received all the attention which it deserves. The inflammation is the expression of a diseased state of the fluids; of what nature, is still a question. It may be the elimination of a poison, or a result of altered nutrition or of altered nervous action. One thing is clear, that the products of the inflammation are of a morbid nature, capable of producing the disease in those who are predisposed to it, and at the part at which they are introduced. Hence may arise the disposition, so remarkable in erysipelas, to spread from the point first invaded. But opposed to this disposition there is the tendency to elimination which exists in the exanthemata, and indeed in disease generally, if the system be sustained in a state of vigor sufficient to enable it to throw off the disease. To a certain extent, then, the local inflammation may be regarded as reacting on the general disease, and anything which would check the local action would so far tend to the removal of the disease generally; just as in small-pox the severity of the attack is greatly modified by rendering the pustules abortive.

It is only on some such assumption that the apparently contradictory facts can be reconciled, viz., that the disease itself is general, the inflammation being only its external manifestation, and that the removal of that external manifestation will aid in curing the disease.

The observations by Velpeau on the effect of the local application of the sulphate of iron have been verified by others. Mr. Luke informs me that, according to his experience, the collodion treatment often cuts short the disease; nay, even mere

position has some influence in arresting its course.

But though these and other measures are beneficial, and at times perhaps effectual in removing the disease, yet cases constantly occur in which they exercise no actual control over it; the disease has too great a hold, or the vital powers are too low, to allow of its arrest by such measures. Nor should they under any circumstances be trusted to alone, valuable as they are when combined with other treatment.

The sulphate of iron, either in a lotion or ointment, produces, as has been said, a decided effect on the inflammation, and tends to shorten the disease. In lotion, a drachm of the salt to a pint of water; in ointment, a scruple to an ounce of lard, may be used. Its effect is very speedy and marked; the redness and tension subsiding, and, if freely applied, the disposition to spread being in some measure checked. But it is an inconvenient remedy, from its soiling the linen with which it comes in contact. The efficacy of collodion in arresting erysipelas is not fully determined. That it is a most useful application is admitted by all. It was, I believe, first used in this affection by Mr. Busk, and is now extensively employed both here and abroad. By Mr. Luke, whose opportunities of testing its efficacy in the London Hospital were very extensive, it is regarded as having an arresting influence over the disease. In a communication which he was good enough to make to me, Mr. Luke informed me that he had abundant reason for believing that the course of the disease might be cut short by the careful and free use of collodion. Mr. Busk, however, attributes to it only a palliative influence. There is no doubt whatever that it forms a uniform and unirritating protection to the sensitive skin. Besides this, it is probable that it acts directly on the inflammation, emptying by its contraction the congested vessels; and there is no doubt that, as in other inflammations, uniform pressure is a most valuable means of relief. But even when the collodion has been applied well beyond the limits of the redness, and the parts beneath it have been rendered pale, the inflammation is often found to continue its spread and pass beyond. By checking the intensity of the local inflammation, however, it no doubt tends to check the severity of the general disorder.

Another agent for which the property of controlling the disease has been claimed, is tincture of iodine, which was recommended by Mr. Norris,[1] who believes that the effect is not merely local, but that "it exhibits a marked control over the constitutional symptoms." I do not know whether this remedy has been employed by others. If it really exercises any influence over the local and general symptoms, it would be well to try the effect of iodized collodion, which is at times beneficially employed in strumous affections.

An application frequently used is the nitrate of silver, first recommended by Mr. Higginbottom of Nottingham.[1] His directions are that "the affected part should be well washed with soap and water, then with water alone, to remove every particle of soap, as the soap would decompose the nitrate of silver; then to be wiped dry with a soft towel. The concentrated solution of four scruples of the nitrate of silver to four drachms of distilled water is then to be applied two or three times on the inflamed surface and beyond it, on the healthy skin, to the extent of two or three inches." Care must be taken that every part be effectually touched, and if the inflammation spread the application must be repeated. Another mode of applying the lunar caustic, especially in erysipelas of the limbs, is the formation of a line a few inches above the inflamed part, completely surrounding the limb. Care must be taken that no part of the circle be left untouched. The inflammation will come up to this line, and there in many cases stop; or if the ring be imperfect, will insinuate itself through the opening, and then spread beyond. In a large number of cases this treatment has appeared to me inoperative, the inflammation passing the line of demarcation, and sometimes even a second and a third line. At other times, however, the inflammation has been arrested. The plan is so simple that it might be well to adopt it in any case, in conjunction with the collodion, or iron, or other application to the inflamed part.

Whatever the application to the inflamed part, strict attention should be paid to position. If the inflammation be in the limbs, they should be elevated; the leg, for example, should be kept in the position which was formerly maintained in fractured patella. This alone will often give marked relief, diminishing action and relieving congestion.

There are not many things which are more comfortable to the patient than a thick layer of cotton-wool placed over the part, to which powder or collodion has been applied. Generally it is more soothing than fomentations, and requires far less attention and exposure. Fomentations, however, when the inflammatory action runs very high, are often desirable, and chamomile or hops will add to their efficacy.

[1] Medical Times and Gazette, Dec., 1852.

[1] An Essay on the Use of Nitrate of Silver in the Cure of Inflammation, Wounds, and Ulcers.

Cold lotions should never be employed; they may indeed check the local action, but with a tendency to invasion of the disease in other situations.

The application of leeches in the early stage, of blisters, of the actual cautery, and of mercurial ointment, has been recommended, and they have all been largely tried. There is no evidence that they have any real effect on the disease, and they are generally abandoned in this country, though still used in France. The objection which exists against general bleeding may be urged against any such amount of local bleeding as would really diminish the action of the part; and unless they are freely applied, they only irritate. Counter-irritation, by blisters or the hot iron, does not appear to shorten the duration of the disease; nor is there evidence that it has been productive of any other benefit. The same remark applies to mercurial ointment, which has the disadvantage that it generally salivates profusely.

The local treatment of phlegmonous erysipelas does not differ in its earliest stages from that of the simple forms. The advocates for depletion of course recommend that more decided antiphlogistic means should be used, and that blood should be taken freely from the part by leeches, cupping, or incision. The two former methods are now little employed, and are rarely productive of any good. The practice of making incisions is one of long standing; and considering the high vascular action and great tension which are present, is one which it might be supposed would naturally suggest itself to the surgeon. According to Velpeau, they have long been practiced in Russia, and amongst the peasants in Brittany. Modern surgery is indebted, however, to Dr. Copland Hutchison[1] for their introduction to the notice of the profession. The plan, which from the year 1814 Dr. Hutchison had adopted largely in naval practice, consisted in making incisions of from an inch to an inch and a half in length, and two or three inches apart, in a longitudinal direction, through the affected limb. Their depth varied according to the nature of the inflammation. In general they reached the fascia, but extended through it when the inflammation extended to the deeper tissues. From fifteen to twenty ounces of blood were usually lost from the overloaded vessels. The hæmorrhage was controlled as far as is possible; a little pressure, with attention to position, generally effected this; the limb was then fomented. The obvious effect of these incisions is to relieve the tension of the skin, to allow of the escape of the accumulated serum and pus where it is formed, and hence to diminish the risk of sloughing of the cellular tissue, and of extension of the suppuration. As phlegmonous erysipelas will often, under proper treatment, end in resolution, it is not necessary to resort at once to incisions; but when the skin is becoming brawny, and it is clear that suppuration is threatened, they should be made at once. Still more important is it to have recourse to them, when that softening occurs which has been before described as indicating that the cellular tissue has fallen into suppuration. Instead of these small incisions, Sir W. Lawrence recommended one long incision extending longitudinally through the whole length of the inflamed part, and thus at times reaching from one end of a limb to the other. This plan is now, however, generally abandoned; the amount of hæmorrhage was in some cases so great as to prove fatal. Nor is the relief afforded to the congested tissues greater than when the safer and milder treatment by multiple incision is adopted.

The practice of scarification, recommended by many of the older surgeons, was again brought into notice by Sir Richard Dobson,[1] who used it in all forms of erysipelas. It consists in making numerous punctures, varying in number according to the extent of the disease, from ten to fifty, and in size from one to two-fifths of an inch. They were repeated twice a day in moderate cases, and three or four times a day in severe ones. According to Sir R. Dobson, only two cases were lost out of many hundreds treated in this way. If used early, these punctures often prove highly beneficial; but if the indications of commencing suppuration be present, it is better at once to have recourse to the small incisions.

When the boggy feel in the part indicates that suppuration has advanced to destruction of tissue, incisions must be freely made, and collections of matter must be at once let out. The suppuration will be abundant, and the dressings must be often changed and the parts cleansed. The matter is always more or less putrid, and it is extremely useful to syringe out the subcutaneous tissue with solutions of carbolic acid or Condy's fluid, or hyposulphite of soda, or with even the undiluted solution of sulphurous acid. I prefer the hyposulphite, using a solution of from twenty to thirty grains to the ounce. The parts should be washed out at each time of dressing. If the discharge be very offensive, a solution of chloride of zinc (fifteen grains to the ounce) will be found more efficient than any of the above. Shreds and flakes of sloughy membrane should be gently

[1] Med.-Chir. Trans., vol. v.

[1] Med.-Chir. Trans., vol. xiv.

drawn away, and it will save time if the skin, which is thinned and blue, and evidently unfit to take on healthy action, is at once removed; but every point of skin or subcutaneous tissue which retains its proper vitality should be carefully husbanded.

It is better to avoid poulticing, which tends to keep up a profuse suppuration. The part should be supported with perforated lint or linen, outside which should be a layer of cotton-wool, and the whole surrounded with a bandage. When the action of the part begins to flag, stimulant washes may be used, or the lint covered with the basilicon ointment. Where the granulating surface is very extensive, the cicatrization will go on to a certain point, and then the process may become arrested, and the modes of treatment required in indolent ulcers must be put in force. It is well to protect the edges with collodion and oil.

The patient's strength must be freely supported, and everything done which will tend to the improvement of his general health.

Nothing can be more contradictory than the statements which have been made with respect to the effect of compression in erysipelas. It was employed by the older surgeons, as Paré, with success; but had fallen into oblivion when Velpeau, in 1826, again brought it into notice. At first he employed it in all forms of the disease, but ultimately he came to the conclusion that, while if employed at the right time and in the proper manner it was almost a certain means of arresting phlegmonous erysipelas, it had no effect on the simple forms. He says[1] that when the phlegmonous erysipelas is only of three days' duration, compression will almost always produce resolution; and that it is still useful even when pus has formed and the cellular tissue has become mortified. Perhaps the compressive bandage has not been so well applied by others, but certain it is that it has not been generally found so efficient as to bring it into general use. The roller should be so applied as to produce moderate but uniform pressure, and should be reapplied every twenty-four hours or less, according to the effect it has in diminishing the swelling. The pressure produced by collodion is more uniform and sufficiently firm; any benefit, then, which can be derived from compression will be more easily obtained by its use than by that of the bandage.

Generally, then, it may be stated, that in the early stages of phlegmonous erysipelas, in the course of the first two or three days, attempts may be made to arrest the course of the inflammation by the means which are found most effective in the simple forms,—such as the use of collodion, of iron, or of the compressive bandage. Should these not be found of any avail in checking it, incisions should be at once resorted to freely and decisively; and they should be resorted to afterwards wherever it may be found that pus is lodged, or that the cellular tissue has been destroyed in parts removed from the neighborhood of those previously made.

The treatment of diffuse cellular inflammation is much the same as that of phlegmonous erysipelas, but it must be more prompt. The chances of resolution are far less, and we have no guide in the skin as to the state of the parts beneath. It is well, so soon as there is evidence that the disease exists, to make incisions at once; but of course hæmorrhage must be carefully checked. The after-treatment must be the same as in the phlegmonous form. Care must be taken that, while the dead tissue has free exit, those parts in which vitality still remains are carefully preserved. Perforated lint spread with basilicon ointment should then be laid over the limb, and surrounded and supported by cotton-wool and bandage, which must be changed as often as the amount of suppuration calls for it.

[1] Leçons Orales de Clinique Chirurgicale, vol. iii. p. 271.

PYÆMIA.

By George William Callender, Esq.

Revised by William Hunt, M.D.

Pyæmia first attracted considerable attention in connection with a condition of veins known as phlebitis, but the expression has now obtained general usage, as conveniently indicating certain effects produced in the system by the action of animal products. For a time, many observers associated it with other changes. Some, following Desault, ascribed it to a disturbance of the nervous centres; others considered it as primarily an affection of the lymphatic system; whilst some have written of its occurrence as dependent upon occult atmospheric causes.

Two conditions may be considered under the name of pyæmia or systemic infection: one the primary or direct consequence of a poison, in which fluid elements are, it is probable, chiefly concerned; the other a series of affections secondary to the primary diseases, or dependent upon other and distinct causes.

By regarding the two as necessarily interdependent, authors have differed much in their explanation of the secondary affections to which the term *pyœmia* is most appropriately applied.

Animal or septic poison, introduced into the system, is the *exciting cause* of the primary disease, *systemic infection*. In no case, however, is its nature detected, far less the cause of its peculiar action, any more than of the virus of small-pox, syphilis, and other affections propagated by inoculation. There is reason to believe that it is connected in some subtle manner with a vitiated condition of the blood, and that it causes changes closely resembling those diseases in their characters. It is possible that such poison may be absorbed through the lungs, or from the alimentary canal; but the cases here to be considered are rather those in which the mischief commences in a diseased or injured part, as an ulcer or a wound; to which surfaces, putrid or other animal matters are unfortunately apt to be frequently applied. It signifies little whence these matters are derived—whether from decomposing pus, unhealthy secretions, decomposing hides, dead bodies, vegetable putrefactions,[1] or from animals suffering from acrid discharges, as in glanders; since the influence of all such, regulated by the intensity of the poison, for they vary in this respect, and by predisposing causes presently to be mentioned, may be conveniently described under two modifications.

In the *first* of these the action is *general*. The poison is rapidly absorbed and diffused throughout the system, either in the veins or by the lymphatics and their associated glands. Within twenty-four hours, in *acute cases*, there are rigors, vertigo, and general uneasiness. Then follow heat, perspiration, and increased rapidity of pulse. The seat of inoculation is dusky, indurated, often pustular, or if it had been before secreting pus the discharge ceases. Radiating from this centre, the integument is distended with a serous effusion, presently to be mingled with thin sanious pus. The swelling, generally somewhat elastic, is hard and tense over enlarging and painful glands. The blood, deranging the heart's action, is circulated violently and rapidly through the system; exuding from its vessels, as in purpura, it stains the surrounding tissues, forms ecchymoses in internal organs, or is poured out upon mucous surfaces, and is then chiefly removed with purging or vomiting. In another twenty-four hours, the patient—flushed, anxious, restless, even delirious—is in a hopeless condition, with prostration and rapid sinking. In other instances the affection is *less acute* in its progress, the poison causes a less disturbance, and the symptoms are insidiously developed. They then simulate those of typhoid fever, to which disease this form of systemic infection bears a close resemblance, and may be recognized as a common cause of death after surgical operations, the patient sinking gradually with symptoms of a low febrile character. If the blood eventually rights itself and the patient recovers, convalescence is slow,

[1] Gaspard, Journal de Physiologie, tom. ii. p. 14.

owing to the feeble condition of the system—a condition caused by direct disturbance from the poison, and by the fluxes of one kind or other which ensue, and aid, perhaps, in eliminating the virus. In this *chronic* pyæmia, as it has been called, successive suppurations may invade the joints or subcutaneous tissues, and the progress of any case may be marked by frequent relapses.[1]

In the *second modification* the action of the animal poison is *local*, is oftener recovered from, and, if fatal, the result is due to predisposing causes, or to changes which depend upon secondary complications.

In these cases of systemic infection *predisposing causes* may be recognized in the habits and constitution of the patient, or in the conditions by which he is surrounded. Predisposing causes intensify the general effect, converting a comparatively trivial local mischief into the worst form of systemic infection, or by their absence render of no effect the most virulent animal poison. Various as they are, they may be grouped under certain well-known conditions. (*a*) Previous illness, either of a chronic character, or especially connected with blood-disease, from which the patient is slowly and with difficulty recovering, as pneumonia, dysentery, or scarlet fever. (*b*) Extreme prostration of the system from organic disease, as phthisis of the lungs, degeneration of the kidneys—conditions often associated with the desponding state of mind noticed in this malady, and by some accounted its cause. (*c*) Exhaustion consequent upon surgical complaints with the eventual shock of an operation, as in diseases of joints,[2] severe fractures of bone, cancer of the breast, ending in amputation. (*d*) Parturition, difficult and protracted, or overtaking women in feeble health, more especially if symptoms arise in the treatment of which depletion is employed, or if in this, or in the previous conditions, diarrhœa or vomiting should interpose. (*e*) Effect of unhealthy occupations and of exposure, as during the war in the Crimea, of which Mounier states, that no pyæmia was noted among the first two thousand amputations, whilst afterwards it became of quite ordinary occurrence, associated with gangrene, scurvy, and typhoid fever. (*f*) Overindulgence in food or in spirituous drinks; sudden abstinence from such indulgences; and, lastly, certain conditions which would seem to be hereditary.

In a word, such circumstances and habits as engender a feeble and unsound state, in which slight injuries produce effects which would never arise in a healthy constitution.

Impure air, such as results from crowding of patients, neglect of their wounds, and of decomposing animal matters discharging from them, also enfeebles, nay prostrates, the sick man; though it by no means gives a special character to the disease, merely reducing him to a condition favorable to the development of pyæmia, erysipelas, gangrene, and other allied disorders. Except as regards ventilation, heat and cold, and their relative effect in the decomposition of animal matter, little stress need be laid upon atmospheric influences. Mental depression is undoubtedly associated with this disease, and its influence may materially aid in the development of systemic infection, and pyæmia, when acting in concert with more directly predisposing causes.

Age does not seem to exert any predisposing influence, for infants alike with the old are apt to suffer from this disease, whilst, as might be expected, figures show that the large proportion of cases belong to the middle period of life, to that in which people are most exposed to the hurts and changes out of which pyæmia is developed.[1]

The most important change which results from the various predisposing causes is a *modification of the blood.* Constituents are probably left in it, unused or unremoved, from defective secretion or embarrassed excretion, some of which are ready, on the least disturbance, to undergo decomposition. Chemistry fails to give us conclusive evidence of these conditions. It is found by many, indeed, that fibrin is deficient—hypinosis—in scarlatina, in cases of exhaustion, of starvation, and in most of those which come under the denomination of cachexia, whilst by others the very contrary is asserted to be the case.[2] Alco-

[1] Paget, St. Barthol. Hosp. Reports, vol. i. p. 2; also Braidwood on Pyæmia, p. 130.

[2] Pyæmia was the cause of death after amputation in—

Bryant's cases.

	Per cent.
All amputations,	10
Amputations of expediency,	70
Primary amputations,	43
Secondary amputations,	25
Pathological amputations,	43

Callender's cases.

	Per cent.
Primary amputations,	0
Secondary amputations,	15.3
All traumatic amputations,	7.1
Amputations for disease,	39.1

—Bryant, Med.-Chir. Trans., vol. xlii. p. 88. Callender, Med.-Chir. Trans., vol. xlvii. p. 75.

[1] For tables of ages, see Braidwood, op. cit. p. 210.

[2] Vogel, Pathological Anatomy of the Human Body, English Trans., p. 69. Bouchut, Mémoire sur la Coagulation du Sang veineux, etc., in Gazette Médicale de Paris, 1845, p. 260.

hol, taken habitually in excess, diminishes the fibrin;[1] and in this, as in most other instances of deficiency of fibrin, the albumen and the fatty principles are relatively increased. Clots when formed within the vessels are soft and infiltrated with serum, forming a gelatinous-looking mass, a tissue of fibrin containing between its fibres a large proportion of fluid serum. They lack contractile power. Lymph, when effused, is laden with corpuscular and granular matter, and soon acquires the character of pus. The blood, when removed from the body, as by hæmorrhage, forms in about the usual time a soft coagulum, buffed and slightly cupped, in which the white corpuscles are found in great excess, as in the blood of women shortly after delivery; it seems in other respects impoverished, and its fibrin is deficient in contractility, as well as modified in actual quantity.

Materials, too, in process of absorption may have entered more or less directly into the blood, as after chronic pneumonia, or may be present in excess during some natural process. Lactic acid in the blood of women after parturition is one of these; and Mackenzie holds that it is capable of producing, when introduced into the blood artificially, the phenomena of some forms of puerperal pyæmia.[2] Whatever the morbid condition may be, the blood in these cases, as noticed by Bouillaud,[3] has a tendency to coagulate in its vessels during life on the least provocation, and then to enter upon other changes.

Systemic infection, then, is caused by some animal poison, and influenced by predisposing causes may become a general disease, more or less rapid in its progress, with symptoms allied to those of typhoid fever, or may be limited to a local action more or less diffused.

Secondary affections may follow the general or the local disease, and were originally more especially referred to under the name "*pyæmia.*" In many of these cases consequent upon general systemic infection, the blood is so altered from its natural state that it simply exudes from its vessels, and diffuses its coloring matter, the rapid progress of the disease leaving no time for further changes. In more chronic cases, local suppurations may be established, chiefly of a pustular character; and in these there is a resemblance to small-pox or scarlatina, blood-diseases, as they are termed, in which pustules or abscesses follow the introduction of a virus, or result from extreme debility.

The *secondary complications* which may follow the local disease (but are often dependent upon conditions different from any of the preceding) are marked by symptoms sufficiently characteristic. The patient, weak and enfeebled by previous disease, or influenced by other predispositions already described, complains suddenly of cold, and is presently attacked with rigors. In nearly all surgical instances—for example, in twenty-eight out of thirty-three of Arnott's[1] reported cases—the patient is described as going on well when the symptoms first become declared. If a wound is suppurating at the time, the discharge often ceases, its surface becomes dry, and the surrounding integument acquires a dusky hue. The rigors, of varying severity, are repeated at brief and irregular intervals; or, though this is the exception, a day or two may elapse before they recur, no symptoms arising in the interval. Perspirations, sometimes profuse and causing considerable exhaustion, sometimes scanty, succeed the rigors. The skin soon becomes dry and harsh, but towards the close of the case, if it terminate fatally, there breaks out a clammy sweat. [If partial and sometimes almost complete adhesion has already taken place, in a stump for example, when pyæmia sets in, there is often a rapid solution as it were of the continuity, the flaps part, and gradually become shrunken and wrinkled, and are frequently covered on their opposing surfaces with a glairy and unhealthy secretion having no adhesive properties about it. Sometimes the shrinkage is so great as to be almost incredible, and bones are left uncovered and projecting notwithstanding most ample flaps were originally made.] The temperature fluctuates, but rarely reaches above 104°. The pulse, rising rapidly to one hundred or one hundred and thirty beats in the minute, is feeble, sometimes intermitting, and though jerking, is easily compressed. The tongue, at first but little altered from its condition prior to the attack, soon grows dry on the dorsum, and is covered with a brownish fur. At the same time there is a remarkable sense of depression. The countenance is anxious and oppressed, the eyes sunken. There is often pain about the head; the patient, restless and irritable, fails to obtain accustomed sleep, and becomes rapidly emaciated. [This emaciation is sometimes promoted by persistent anorexia. The very sight of food is abhorrent, and when this symptom is present, there is a cloying sense of sweetness in the mouth, and the

Becquerel and Redier, Pathological Chemistry, English Trans. p. 56.

[1] Huss, Alcoholismus chronicus, Stockholm u. Leipzic, 1852. Peters On the Pathological Effects of Alcohol, in New York Journal of Medicine, vol. iii. No. 9.

[2] Mackenzie, Med.-Chir. Trans., vol. xxxvi. p. 210.

[3] Bouillaud, Archives générales de Médecine, 1823, tom. ii. p. 189. Bouchut, op. cit.

[1] Med.-Chir. Trans., vol. xv.

breath has a peculiar unpleasant sweet odor, suggesting the presence of diabetic sugar, which may or may not be in the urine.]

With these symptoms there exists a tawny discoloration of the integument almost characteristic of the disease, requiring, however, to be distinguished from the jaundice tinge with which it is sometimes complicated. Without the intercurrence of other symptoms, the patient may pass quickly into a typhoid state, and thus, in a few days, the disease may terminate fatally, or, less rapid in its progress, may tend to gradual sinking, the patient lingering[1] for several weeks.

When any one organ is especially involved, new symptoms arise. Delirium, rarely of a violent character, with pain about the head, the patient growing heavy and drowsy, answering only when roused, and then with hesitation and indistinctness, points to the nervous centres as chiefly implicated. Hurried respiration, dyspnœa, slight cough, sense of weight about the heart, or pleuritic pains, point to the thorax and its contents. Sickness and vomiting, or diarrhœa with bloody stools, containing shreds of fibrin, mucus, and pus, point to the intestinal canal, and recall the fact that this disease is sometimes associated with dysentery. Diarrhœa with copious bilious evacuations points to the liver, as also do stools consisting of crude food without any bile, especially when combined with jaundice; and this is confirmed by pain in the hepatic region. The bladder and kidneys are seldom affected.

These local symptoms show where the stress of the disease is borne; the main symptoms, those of depression and prostration, advance the while. In the extreme exhaustion at the close of this malady, it is not unusual to observe discharges from various surfaces, as from the nostrils, from the ears, or from the uterus in the female, or to meet with effusions into serous or synovial sacs. For the patient, with a sudden complaint of pain, will often draw attention to a joint, swollen and rapidly distending, or several articulations may be found painlessly implicated in the disease. Nor is it unusual to see on the integument patches of dusky discoloration, as though local deaths were commencing before dissolution, or to notice pustular eruptions, or the rapid development of boils.

It is unnecessary to describe the muttering delirium, the parched tongue, the lips discolored with sordes, which prelude the fatal termination. The symptoms are the same as those of low typhoid fever.

Few recoveries from the acute secondary complications are recorded; and even in these the symptoms mark an early stage, when the existence of this disease has been suspected rather than proved. In isolated cases, patients have recovered after severe rigors, followed by some of the local symptoms, as dyspnœa. Expectoration of puriform mucus from the lungs, the passage of bloody and copious stools observed in these recoveries, have been regarded as eliminating processes by which the system is relieved of the morbid material influencing the blood.

Many *pathological changes* are found in the dissection of fatal cases. Some of these are referable to a primary disease, others to the secondary complication.

Amongst primary affections may be observed diffused suppuration, as that which accompanies the second modification of systemic infection. Pus, or pus mingled with serum, is then seen infiltrated through the tissues, more especially the cellular, or limited to the course of the arteries, the veins, or the lymphatics. Such suppuration may have extended from a wound, as after an operation, or it may start from a fractured bone, or may-be from inflammation of internal parts, as of the pleuræ, of the lungs, or of hydatid tumors, whilst in other cases, the process may have commenced about ulcers, as of the integument, or of the mucous membrane, as in dysentery.

In the midst of these suppurative changes, the veins are found filled with clots, and these clots undergoing various changes. It must here suffice to state,[1] that, at first of a deep red tint, they become brown, or of a rust color; the red corpuscles diffuse their contents and lose their shape; the clots then soften, and presently become diffluent, so that, after a short time, varying from a few days to a week or more, they form a yellowish fluid resembling pus, or have a sanious appearance from being mingled with coloring matter of a deeper tint. Gulliver[2] first drew attention to these changes, and they have been since examined by Bristowe, Virchow, and others. These conditions, it is true, can be demonstrated only in veins of considerable calibre, but it is reasonable to believe that they occur in the smallest branches, as at the base of an extending ulcer, or around a suppurating tissue. Hæmorrhage is chiefly prevented by the closing of such vessels with coagula, with-

[1] After operations the symptoms of pyæmia have commenced any time from the second day to the third or fourth week. After parturition they usually commence within the first ten days. The patients have sometimes lingered for two or even three months.

[1] For further consideration of the disease of veins referred to, see the article DISEASES OF VEINS.

[2] Med.-Chir. Trans. vol. xxii. p. 136.

out which they would of necessity bleed when their walls break down in the progress of the disease. The clots once formed, changes ensue (the predisposition being the same) similar to those in other veins; only, as a rule, the larger the vessel and the greater the extent of softening coagulum, the more serious and rapid are the secondary effects. Although the tissues around such veins, and even the outer wall of these vessels, may be the seat of diffused inflammation, it cannot be too strongly urged that ordinary pus is never found in their interior on dissection, except when an abscess bursts into their canal; and there is no evidence that their lining membrane inflames, although it may be involved in gangrenous processes.

In other cases there are conditions of even more common occurrence than the preceding, which occasion the formation of the clots. Small vessels, ruptured in contusions and causing ecchymoses, are often closed by coagula, conservative against hæmorrhage, but sometimes dangerous from their insidious extension[1] and subsequent disintegration. Their presence is recognized in some cases of failure in the union of bones broken near the medullary foramen. They may extend from ecchymoses of the surrounding tissue into a femoral or other principal vein, and to the sinuses of the brain after injuries of the scalp. The case of a man, aged sixty-two, illustrates this mode of formation and extension of coagula. Whilst following his ordinary employment he fell heavily on his left hip, and sustained a fracture at the neck of the femur. He sank four months after the accident from chronic bronchitis. The rectus muscle and the adductors were greatly ecchymosed, and there was a considerable ecchymosis by the side of the femoral vein as it lay upon the adductor longus. The superficial veins were unaffected, but many of the more deeply-seated were filled with coagula softening at the centre. These veins were found entirely upon the inner side of the thigh, in the vicinity of the ecchymoses. They opened directly into the femoral, which was filled by a decolorized clot, about two inches in length, terminating at the junction of the external circumflex, just below the profunda, Fig. 95, *b*. This clot was soft, and disintegrated at its centre so as to resemble pus, Fig. 95, a^2. The inner coat of the vein was natural, and there was no suspicion during life of the existence of the coagulum.

Another man, also sixty-two years of age, was brought into St. Bartholomew's

Fig. 95.

Femoral vein containing a clot.

Hospital suffering from symptoms of concussion, which followed a fall on the vertex, with laceration of the scalp. He quickly recovered from the immediate effects of the accident, but died on the twenty-sixth day with symptoms of pyæmia. The veins opening into the superior longitudinal sinus were distended with disintegrating coagula, and the sinus was filled from end to end in the same manner. Its walls were natural, and the adjacent membranes of the brain were free from inflammation, nor was there any fracture of the skull, but in the immediate vicinity of the smaller veins there existed several slight ecchymoses. The lungs were filled with secondary deposits.

Many such cases might be referred to, if necessary; but the above are sufficient to illustrate the fact. Similar clots, extending from the placental surface of the uterus, assist in explaining cases of puerperal phlebitis not due to diffused inflammation of the cellular tissue around the pelvic veins. The probable connection between these clot-formations and the secondary abscesses will be subsequently considered.

The post-mortem appearances which belong to the secondary affections accompany some one or more of the preceding conditions. The following table of thirty-one cases, taken in sequence from the report-books of St. Bartholomew's Hospital, shows their more frequent situations, and the relation of each to a primary disease.

[1] In these and other cases it has long been known that no serous infiltration of the part necessarily follows the occlusion of even the principal venous trunks. See Bouillaud, op. cit., p. 190.

[2] Museum of St. Bartholomew's Hospital, series xiii.

CASES OF PYÆMIA.

Nature of the primary affections.	Situation of the secondary complications.	No. of cases.	References to the cases in the first column.
1. Phlegmonous inflammation of scalp	Lungs	23	1, 2, 3, 4, 5, 8, 10, 11, 12, 13, 14, 17, 18, 19, 20, 21, 24, 25, 26, 27, 28, 29, 30.
2. " " mediastinum			
3. " " leg			
4. Diffused infl. of pelvis after lithotomy			
5. Pelvic cellulitis	Brain	8	1, 6, 17, 20, 23, 28, 30, 31.
6. Wound of scalp			
7. Gunshot wound of ilium	Liver	7	4, 12, 15, 19, 22, 28, 29.
8. Compound fracture of femur			
9. " " "	Kidneys	7	9, 13, 14, 17, 19, 29, 30.
10. Amputation of thigh			
11. " "	In joints 2	6	7, 16, 24, 25, 29, 30.
12. Empyema	Around joints 4		
13. Empyema	Muscles	4	7, 18, 24, 30.
14. Empyema			
15. Typhoid ulceration of small intestine	Heart	4	1, 13, 29, 30.
16. Dysentery			
17. Dysentery with rheumatism	Spleen	2	14, 20.
18. Eroding ulcer of spleen			
19. Suppurating hydatid in omentum	Skin	2	24, 30.
20. Abscess in lungs			
21. " liver	Bones	2	18, 27.
22. " uterine wall			
23. " orbit	Intestine	1	30.
24. " neck			
25. " sterno-mastoid muscle	Prostate	1	1.
26. " axilla			
27. " around diseased hip-joint	Uterus	1	31.
28. " in thigh			
29. " over left radius	Trachea	1	2.
30. " over right tibia			
31. Cancer of uterus	Intestine	1	17.

Although the capillaries of the lungs, coming first in the order of the circulation with reference to the primary disease, are most frequently involved, the above table, which fairly represents the results to be obtained from the cases reported by various observers, shows that the secondary affections are by no means limited to the first set of capillaries, but implicate with much irregularity various parts of the body. They present the following appearances.

When present in the lungs, the secondary disease involves more frequently the left than the right viscus; it occupies the lobes indiscriminately, and lies beneath the pleural surface or deeper in the pulmonary tissue. When superficial, the serous covering is usually inflamed; and soft lymph smeared over its surface, and yellowish shreds hanging from it, at once point out the situation of the deposits. Sometimes the pleural sac is even filled with pus, which is usually thin and laden with lymph-masses. The deposits are easily detected by touch, hard, resisting, and isolated amidst crepitant lung-tissue. When cut across, they present, according to the progress each has made, some such conditions as the following: In those just formed there are small ecchymosed spots, caused by stasis of the blood in some of the capillaries of a lobule. This red consolidation extends until the whole lobule is involved, and then stops, probably where the artery branches off before entering it. Unless two adjacent lobules happen to be simultaneously affected, these changes are at first limited to one, and this explains their tolerably uniform size in this their commencement.[1] The vessels are simply filled with coagula; for the lobule, though solid, is not gorged with blood, nor does it bulge and so compress those which lie around. After a short time the parts first consolidated begin to acquire a rusty tinge, then a lighter brown, at the same time softening and presently becoming diffluent; minute yellow specks appear and extend, or sometimes the brown or sanious color persists, surrounded by the red ring of as yet unaltered coagula, and if now examined under the microscope, they are found to consist of fatty granules, amorphous débris, and altered blood-globules. These changes are quickly succeeded by others. Irritation is kindled in the parts around, which become

[1] See Lee on Phlebitis, p. 29.

red, congested, and this time with effusion or rapid cell-growth, so that when the lobule first affected is thoroughly disorganized, it is infiltrated with materials which reach it from the surrounding inflammation, and its contents are mingled with ordinary pus-cells. This advanced condition constitutes the abscess as usually observed, and described as a collection of pus surrounded by congested pulmonary tissue of a deep crimson color. These abscesses now vary greatly in size, so that the same lung contains some no larger than a pea, and others which form masses of considerable extent. No satisfactory evidence has been offered to show that their progress is ever arrested, and repair or cicatrization commenced. Their contents are never found thickened, drying up as it were, with puckering and shrivelling of the surrounding tissue. The expectoration of fibrin-like matter from the lungs, in cases of supposed recovery, has, however, induced the suggestion that such changes may in rare instances ensue.

Liver.—Secondary deposits commence in this organ by the filling here and there of portal capillaries and associated veins with colored clots, so that they are distinctly mapped out upon a cut surface of hepatic tissue. The subsequent and surrounding congestion is less intense than in the lungs, owing to the coarser character of the capillary network, but the change in color,

Fig. 96.[1]

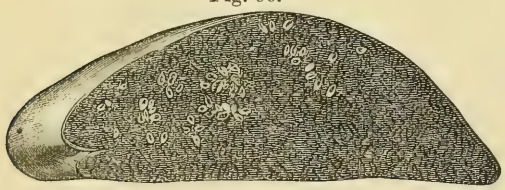


Fig. 96, and the softening take place as rapidly. At this stage the microscope enables us to detect amorphous material, fat-granules, and a sprinkling of hepatic cells, but no pus-corpuscles. There ensues an exudation into the neighboring tissues, which are soon infiltrated with lymph and serum. This softens, and, in the unhealthy condition of the system, is quickly mingled with pus, and so an abscess is formed. But as yet before the abscess is confirmed a very characteristic appearance is presented. A number of firm nodules of a yellowish color are conspicuous; these are the occluded vessels, representing the outer part of the lobules; around them is a pale-gray, jelly-like network, inclosing them as it were, and this is the surrounding effusion of lymph and serum. Even after the softening of the fibrin and the formation of pus, the abscess retains some trace of its origin; for when the pus is washed away, a mass of tough tissue remains, in which can still be traced the skeleton of the lobules.

As surrounding parts are involved, they pass through similar changes, so that in the same liver may be seen fibrinous plugs, lobules with lymph effused around, and abscesses of varying size, in their turn bordered by exudation-materials, for no distinct wall invests them, and in their general characters forcibly calling to mind the diffuse suppuration of subcutaneous tissue as distinguished from a simple abscess. If from any circumstances the diffusion is arrested, the diseased lobules are soon bounded by organizable lymph, and in some cases the wall thus formed becomes thick and membranous, after the fashion of that which lines a chronic abscess. At the same time the contents thicken and begin to dry up, as though a curative process was commencing; further changes are, however, usually prevented by the death of the patient, so that there remains a doubt whether these abscesses are ever completely cured in cases reported to have recovered after symptoms indicative of their presence.

Skin.—Lee has recorded[1] three conditions of the integument as observable in these cases, which seem to be modifications of one another. First, a pustular eruption resembling that of small-pox; secondly, irregular spots of congestion of a dusky color; and thirdly, congested patches darkest in their centres, rapidly passing into mortification, usually with extension of the congestion to parts around, though sometimes limited by a line of demarcation. These patches are apt to form at points subjected to pressure.

Changes similar to those in the lungs and liver occur in other organs with immaterial variations.[2] The situation of the secondary deposits is capricious, not merely as to the organs which they involve, but as to the part of each organ implicated. The more vascular tissues are of all most prone to be affected, but it is in the least vascular that the subsequent changes are most rapid, as, from the more complete cutting off of blood supply, gangrene most constantly ensues. Wherever secondary deposits are developed, they may in turn, if the patient's life be sufficiently prolonged, become the source of others, which pass through similar changes, and may be termed for distinction tertiary.

[1] From a drawing in the Museum of St. Bartholomew's Hospital, No. 271, showing part of a liver with the portal capillaries and associated veins of many lobules filled with decolorized coagula.

[1] Op. cit., p. 53.

[2] For résumé of brain-mischief, see Braidwood, op. cit., p. 168.

Other Secondary Affections.—Effusions into serous or synovial sacs, commonly into those of joints and of the pleuræ, rarely into the ventricles of the brain, constitute another class of changes. The ordinary secretion may be increased, becoming in the case of joints less viscid than natural; or there may be an effusion of serum, or lymph, or an accumulation of pus, or of pus stained with blood. In some cases, the cause of these changes may be traced to irritation from a collection of pus somewhere close at hand, as beneath the pleura, or in the tissues which immediately surround joints. The effusions occur without material congestion, and generally towards the close of fatal cases.

In considering the *causes* of the secondary complications, it may be remarked that the frequent occurrence of these secondary abscesses after surgical operations has induced many observers to offer explanations of their origin. From the mass of writings upon the subject, it is necessary to select the views which have received the greatest amount of credit, and to relate the arguments by which they have been supported.

It is generally admitted that secondary complications (abscesses) may result from mere poisoning of the system in connection with any of the causes of systemic purulent infection; but without doubt a large number of cases exist in which those secondary affections are dependent upon local diseases, and are due to mechanical obstructions in the smaller vessels, affections occurring when the blood is ill nourished and the patient exhausted, but affections which are not necessarily dependent upon a general poisoning of the system, but are connected rather with its prostration and the end-coming of its life. It is to such cases that the following observations especially apply.

PUS INTRODUCED INTO THE BLOOD.

Of all exciting causes none has been more generally insisted upon than this, and many arguments have been brought forward in its favor. The connection of the secondary complications with a primary local suppuration, the presence of pus-cells in the blood, the characters of the secondary affections, and the results of experiments, are its principal props. These must be severally examined.

Connection of secondary complications with a primary local suppuration.—When phlebitis was attracting general attention, it was observed to be frequently followed by secondary deposits. On further examination, phlebitis was found to exist in most cases of pyæmia, and nothing was more natural than to look upon the two as closely connected. Attention had been already drawn by Boerhaave, Morgagni, and Desault[1] to the presence of secondary abscesses after ulcers and after suppuration, involving more especially the brain, and they had been ascribed by the latter to some nervous influence; but, although Tessier supported the doctrine of a purulent diathesis,[2] most writers, including Rose, Dance, and Arnott,[3] inclined to the view of their dependence upon the introduction of pus into the blood. So long, then, as phlebitis was believed to give rise to suppuration within the veins, the coexistence of these secondary affections was easily accounted for. Either from breaking down of the clot which should have limited the suppuration, or from absence of such clot owing to a degenerate condition of the blood, the pus, it was argued, directly or through some collateral branch, found its way into the general circulation.

But cases coming under notice in which no phlebitis could be demonstrated, it was observed of these that they accompanied some form of suppuration, such as that in wounds after operations, that of diffused inflammation of internal parts, as the mediastina, or abscesses in bone, and other structures, as, for example, the prostate gland.

The idea of the absorption of entire pus-globules through the walls of veins was speedily abandoned; and although some maintained that putrid serosity alone found its way into the circulation, and so excited the diseased action, the belief gained ground that the pus passed into the open orifices of veins—a supposition strengthened by the frequency with which, as noticed by Cruveilhier, the secondary affection followed injuries and operations upon bone, in which tissue the veins, it is well known, neither collapse after division, nor contract upon the clots which form and afterwards shrink within them. In other cases, it was urged, the opening in the vessels might result from ulceration and sloughing of their walls; and the irritation of a surrounding suppuration was supposed to reopen even those veins which had been closed in the healing of wounds.

On the other hand, it was noticed how often pus might get into the blood and yet no symptoms of pyæmia ensue, and how many secondary affections occur before any local suppuration has been established. It

[1] See Morgagni, De Sedibus et Causis Morborum, lib. iv., epist. 51, art. 17, 18, 19, 20. Riber, Recherches sur la Phlébite, in Revue Médicale, tom. iii. Quesnay, Mémoires de l'Académie Royale de Chirurgie. Paris, 1819.

[2] Tessier, Exposé et Examen critique des Doctrines de la Phlébite, etc. Paris, 1838.

[3] Rose, Med.-Chir. Trans., vol. xiv., p. 251. Dance, Archives générales de Médecine, tom. xviii., p. 473; xix., 5, 161. Arnott, op. cit.

is now known that the lining membrane of veins rarely presents evidences of inflammation; that it probably never secretes pus, and that the appearance of suppuration noticed in these vessels is in truth caused by softening clots.[1] The above views are, therefore, in part, untenable.

The presence of pus-cells in the blood.—Healthy pus applied to blood as it flows from a vein hastens coagulation simply as a mechanical agent. It does not mingle with that fluid, but coagula form around in from two to three minutes, and the coagulation is slowly diffused. Serous pus and the serum of decomposing pus cause more general coagulation; for as they incline to mingle with the blood, they present a greater number of centres for coagula to surround.

And it should be observed of the experiments from which these results were obtained, that the pus was simply dropped into the blood, and not stirred up with it, whereby undue artificial mingling was avoided.[2]

After injection of small quantities of pus into the veins of living and healthy animals, none of it can be found in the allied venous trunks; but, traced beyond these, it is recognized as arrested in the first set of capillaries in the course of the circulation, so that its corpuscles undoubtedly circulate with the blood, though it is reasonable to infer, from their action upon that fluid out of the body, that they become capsulated with fibrin as they flow onward, and that by the same process their size is modified. Now, many observers go so far as to affirm that, in the disease in question, they can recognize pus-cells in the human blood, scattered amongst the red discs (when viewed with the aid of the microscope), the latter retaining their usual appearance, except when the pus is present in large quantities. Under such circumstances, Gendrin states that blood-corpuscles are converted into pus-globules; and mingling pus and blood in the proportion of one to eight, he proves that, after twenty-four hours, none but pus-corpuscles can be detected. But Gluge and Vogel have shown that pus, acting like water, simply dissolves the capsule of the corpuscles, and that this is the cause of the modification noticed. All, however, agree that pus-cells, when present in small quantity, do not interfere with the red discs, from which they are easily distinguished. It is from their resemblance to the white corpuscles that their detection is rendered difficult and doubtful. Granting they have entered the circulation, can then the pus-globule be distinguished from the white blood-corpuscle? Sédillot,[1] who has carefully considered this question, is confident in the distinction to be drawn between the two. "The pus-globule," he says, "is $\frac{1}{100}$ to $\frac{1}{80}$ of a millimetre in diameter, whilst the white globule is $\frac{1}{120}$ to $\frac{1}{100}$, a sixth or a fifth smaller. The pus-globule is slightly yellowish, the other is a dead white. The pus-globule is spherical, the white one flattened, being at most lenticular but never spherical; its surface is smooth and indistinct, whilst that of the pus-globule is roughened or granular. The nuclei, when shown by means of acetic acid, are found larger, $\frac{3}{100}$ to $\frac{2}{100}$ of a millimetre in diameter in pus-cells, and exhibit in their interior a regular, well-defined cavity; while white corpuscles contain nuclei much smaller ($\frac{3}{100}$ to $\frac{1}{100}$), resembling nucleoli or rather fatty granules. The white," he adds, "when present are less numerous than the others." How far these differences are available for diagnosis, those can well judge who are in the habit of examining such cells under the microscope. If present, the pus-globules may disorganize the blood in some subtle manner, causing its fibrin to separate and coagulate here and there in the capillaries, or they may determine secondary abscesses by their mechanical arrest and by the changes which then ensue.

Dance and other observers,[2] however, are unable to detect these pus-globules, or altogether deny their presence in blood. Some explain their absence by suggesting that they are mechanically compressed, and so no longer recognized, just as they entirely lose their character when mingled in small quantity with blood out of the body, and entangled in contracting fibrin. The experience of many observers shows, in opposition to the opinion of Sédillot, that the white globules are greatly in excess in all these cases, even in those in which no source of pus-cells has existed; that their number is naturally very variable; that it increases rapidly after certain processes, as digestion; and that they are abundant during pregnancy, and for some time after delivery. Whilst, then, uncertain of our ability to distinguish between the two, the differences being trivial and difficult to detect, even as described by those most favorable to their recognition, the fact of our having under many, perhaps under all, circumstances favoring pyæmia, an excess of white corpuscles, prevents the evidence in favor of the presence of pus-globules in the blood from being accepted as conclusive.[3]

[1] See article on DISEASES OF VEINS.

[2] See Mackenzie, op. cit., p. 196; Lee, op. cit., p. 26.

[1] De l'Infection purulente, p. 262, note by Lebert. Paris, 1849.

[2] Donné, Cours de Micrographie, p. 82. Paris, 1844.

[3] On the points of resemblance between py-

Character of the Secondary Abscesses.—These having been examined when completed, to the exclusion of the preliminary changes, and being found laden with pus, were naturally adduced in favor of the theory of their purulent origin. It is now certain that no pus-cells are found in them at their commencement.

Results of Experiments.—It has been proved at various times, by the injection of pus into the veins of living animals, that veins inflame; that veins do not inflame; that local coagulation immediately results, or, as Magendie states, that coagulability of the blood is destroyed; that the injection is followed by fibrinous deposits; that it is followed by purulent deposits; that pus-globules, when mingled with their serum, cause most rapidly the secondary affections; and, on the contrary, that pus-corpuscles, when separated from their serum, produce them most certainly;[1] but these different results are intelligible enough if the difficulties which beset experiments of this nature, and the extent to which observers are always biased by the doctrines of the day, are duly considered. Repetition of the most important leaves no doubt that the more recent experiments have been accurately observed, though great allowances must be made in drawing deductions to be applied from them to the human subject, if only on account of the healthy condition of most animals operated upon, and the slowness with which they take up diseased actions, especially of a suppurative character. The results obtained may be briefly shown in a series of typical cases.

(1) After single injections of pus, animals, if previously healthy, usually recover; so that four to twenty grammes were often injected by Sédillot without causing inconvenience; but that this is not invariably the result, is shown by the following experiment.[2] One-half drachm of recent pus, injected into the right femoral vein of a dog, caused immediate death. The femoral and allied veins, as far as the right auricle, that cavity, the commencement of the vena cava superior, and the right ventricle, were filled with a continous dark-colored coagulum, in various parts of which portions of the pus were sequestered. The blood was fluid in the veins of the opposite side, in those of the head, and in the left cavities of the heart.

(2) Simple inoculation with pus of the tissue surrounding a vein is followed by slight local suppuration, the blood remaining unaffected in the adjacent vessel; and no change results from the application of pus to the edges of wounds in venous trunks, although in these experiments some pus-globules probably pass into the circulation. The wounded veins are repaired in the usual manner.

(3) Injections of small quantities of pus are usually followed by secondary deposits. About eight drops of pus were injected into the right femoral vein of a small dog. The animal, on recovering from the chloroform, refused food, and after twenty-four hours began to snuffle. It was killed, by division of the spinal cord, at the forty-eighth hour. The vein was natural from the ligature upwards. The lungs were irregularly studded with spots of a red color, averaging a line or two in diameter. These consisted of minute vessels gorged with blood, probably coagulated, for it could not be removed by pressure. Their uniform appearance depended upon their limitation to single lobules.[1] Examined under the microscope, they were found to consist of ordinary constituents of blood mingled with granular cells.

(4) If the animal is in a healthy condition, the secondary appearances pass off. At the same time as the last experiment was performed, about twenty drops of the same pus were introduced into the right femoral vein of another dog, and the animal was killed at the ninety-eighth hour. The veins were healthy throughout. In the left lung only one, in the right two small ecchymoses still existed, similar to, only rather darker than, those noticed in the preceding experiment. The other organs were natural.

These examples are taken from amongst many, and are easy of repetition; they serve to illustrate the fact that pus is arrested in the first set of capillaries, and that the blood-stasis which ensues presently rights itself and eventually clears off.

(5) The secondary abscesses are obtained by Sédillot[2] and others by injections repeated at intervals, in animals consequently enfeebled by disease. Similar results may be obtained in dogs which are let blood before introduction of the pus, three or four days being allowed to elapse before the abscesses are looked for.

(6) Similar or allied results follow the injection of many other substances; thus, decomposing serum mingled with pus-

æmia and leucocythæmia, see Dr. Hughes Bennett, quoted by Braidwood, op. cit., p. 227.

[1] Reumert, "De Symtomatibus Inflammationis Venæ Cavæ. Diss. inaug.," Havn. 1840; Gendrin, Histoire anatomique des Inflam., vol. ii., pp. 13, 14; Mackenzie, op. cit.; Gaspard, op. cit.; Lee, op. cit.; Sédillot, op. cit.

[2] The experiments here narrated, originally described by various authors, have been repeated by the author to corroborate their accuracy, and those thus repeated are here cited, as they agree in the main with the originals.

[1] Museum of St. Bartholomew's Hospital, series xiii.

[2] Sédillot, op. cit., p. 128.

débris causes even more diffused effects than pus, and, acting more after the manner of the poisons alluded to as causing systemic infection, gives rise to local gangrenous lesions, with considerable extravasation of blood into surrounding tissues. Experiments have been recorded by Cruveilhier and Gaspard showing some of the substances besides pus which are arrested in the capillaries; thus the latter writes: "Les corps trop grossiers, tels que le mercure, l'huile, le sédiment de l'extrait d'opium, etc., ne peuvent pas outrepasser les petits vaisseaux intermédiaires aux artères et aux veines;" and both describe the formation of the secondary abscesses. Gaspard's[1] experiments also prove that similar substances, carried rapidly through arteries, produce violent local irritation in those parts only to which the branches of the injected artery are distributed.

(7) It happens sometimes that pus—and it is only of pus the fact has been recorded—slips by one set of capillaries, as in a case narrated by Sédillot,[2] in which, the mesenteric veins being injected, the liver remained unaltered, whilst the lungs became the seat of secondary abscesses. This cannot be ascribed to any difference in the size of the two sets of capillaries; but it has led to the suggestion that pus-globules are only arrested in their course when they become aggregated, or increased in bulk by the addition of materials from the blood.

Thus, although the secondary complications seem to follow upon the introduction of various substances[3] into the blood, of which pus is one, and probably depend upon their mechanical arrest in vessels intermediate between the arteries and veins, yet on applying the results of these experiments to the human subject, they are met by the facts that pus-globules are not of a certainty found in the blood; that the secondary abscesses are often unconnected with any primary local suppuration; and that they are not in the first instance purulent.

With the exception of decomposing serum and other fluids of an allied character, which can only excite the complications by setting up some vital or chemical action, there is but one material other than pus by which to explain the mechanical origin of the secondary changes; but this material is so generally present in this class of cases of pyæmia, that it requires separate consideration.

[1] Gaspard, op. cit., tom. v., p. 319; Lee, op. cit., p. 39.

[2] Sédillot, op. cit., dix-huitième expérience, p. 101.

[3] Amongst these fibrin should be enumerated. See Sédillot, op. cit., onzième expérience, p. 86; also p. 110.

Before entering upon its consideration, however, a few words may dispose of the theory of a purulent diathesis, which, indeed, proposed in times long past,[1] refers to what is now regarded as the unsound condition induced by predisposing causes, in which the system is prone to suffer from suppurative or typhoid diseases. In the same way may be dismissed such theories as presuppose that fibrin about to be eliminated into pus undergoes a retrograde metamorphosis, is carried on in the circulation, and causes like actions to go on in the accompanying fluid; also the older, but less far-fetched idea, of the influence of a nervous action; a view entertained in consequence of observations by Desault on secondary affections connected with injuries to the skull and its contents. With these may be classed absorption by the lymphatics, which of late years has been, by most observers, discarded as a cause of the secondary complications. The cases which are quoted in its favor are found, on inquiry, of a doubtful character; some are incorrectly reported, as can easily be seen, now that more is known of the subject; for example, Dumas narrates several in which the lymphatics about the uterus (mistaken, doubtless, for the veins) were filled with pus, which, however, could not be detected in the associated glands, where it was consequently supposed to be in some way elaborated.[2] Other cases have been examples of diffused inflammation in the course of the lymphatics, or have been connected with changes independent of the absorbent system.[3]

An ingenious idea, applicable more especially to cases in which pyæmia follows surgical operations, as after excision of a testis, or amputation of an extremity, has been originated by the suggestion that materials, harmless to those organs and textures to which they should have been applied, when unused or unremoved from the blood, act as local irritants to other structures, and so engender secondary mischief, such as effusion of puriform fluid into joints. These materials may have affinity with chemical substances, but they do not admit of recognition by physical means.[4] Chevers lays great stress upon previous abdominal complications, observing, "It is highly probable that, in most of the individuals who thus perish, even if they had never become the subjects of any wound or injury, some other vicissitude would, by bringing the renal or hepatic mischief into active operation, have

[1] De Haen, Ratio Medendi, tom. i., p. 102 et seq., Paris, 1761; also Tessier, op. cit.

[2] Dumas, op. cit., p. 106.

[3] Lee, op. cit., case xxix.

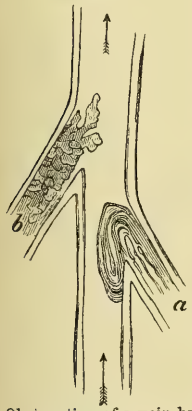
[4] Finger, Präger Vierteljahrschrift, No. iv., 1847.

equally determined the occurrence of fatal cerebral, thoracic, or abdominal inflammation.''

Disorganized Fibrin introduced into the Blood.

As is more fully detailed in describing diseases of veins,[2] coagula are formed in these vessels, with inflammatory changes of adjacent tissues and of the outer wall of a vein itself, or in veins ruptured by violence. When a predisposition exists, very little is sufficient to cause their deposit. Bouillaud[3] writes of them as often noticed in the cachectic from simple pressure, in the veins of the pelvis from compression by cancer of the ovaries, and in the internal iliac from distension of the sigmoid flexure with hardened fæces; and, as bearing upon their connection with pyæmia, Tweedie mentions a case in which this disease followed a contusion of the thigh; Lee, one after a blow upon the patella. These coagula, when formed in a small vein, are limited in either direction by the first collateral current, though they may extend past one or more of these into larger vessels involving at last important canals, if aided by predisposing circumstances, and by a blood-condition thereon dependent. Disregarding the influence of any surrounding inflammation, and looking at them as hindered in their extension by the action of the blood as it sweeps past them, they may at first encroach upon and in time pass these currents by the addition to their surface of irregular plates of fibrin, as shown in the accompanying woodcut (Fig. 97, *a*); an encroachment which may be prevented if the greater force and capacity of the collateral stream be sufficient, even under adverse predisposing circumstances, to keep clear its channel. Once arrested in their progress, particles may be loosened and carried off from their surface, where washed by the flowing blood, and then pass on through the veins and heart (Fig. 97, *b*) each forming an embolon or plug, entering pulmonary arteries of a smaller and lessening diameter, until they at length lodge, usually at a bifurcation, where, as after the application of a ligature, new clots form upon them. These detached portions undergo various changes, and, if cutting off any considerable supply of blood, may cause even gangrene of the part involved. They are of interest, in connection with clot-softening and disintegration, as showing how smaller particles when circulating with the blood, produce even more noticeable effects.

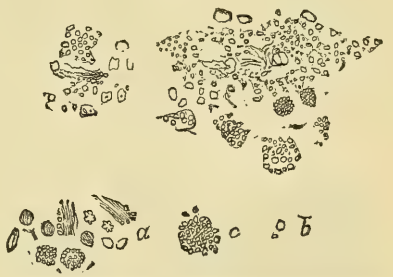
Fig. 97.



Obstruction of a vein by growing coagulum.

Whatever may be the cause of this softening of clots, the fact is undoubted, and has been carefully studied in connection with the clots, or polypi, as they were formerly termed, which are found under certain circumstances in the cavities of the heart, and in the venous canals. It is probably associated with that unhealthy condition of fibrin, whereby it is wanting in contractility, and retains in its meshes an undue quantity of serum. The disintegration commences in the oldest portion of each coagulum, so that it may affect one side, one extremity, or the middle of a clot, as the case may be; it is accompanied by the changes in color already described, and, from their often acquiring the appearance of ordinary pus, the earlier observers were led to consider these clots as true purulent collections. When examined under the microscope, they are found to contain (Fig. 98, *a*) blood-cells variously modified; some mere shreds, others serrated and puckered; some probably white corpuscles, being pale and transparent when acted on by acetic acid. These are entangled amidst a quantity of granular matter and globules, composed, perhaps entirely, of oil soluble in ether (Fig. 98, *b*); here and there many of these granules and globules form masses of very variable size, irregular in their outline, though sometimes having a surrounding cell-wall (Fig. 98, *c*), which, however, can seldom be demonstrated. These also are soluble in ether. Lastly may be noticed irregular masses of varying size—portions,

Fig. 98.



Microscopic appearance of softened coagulum.

[1] See Simpson, Med. Times and Gazette, vol. i., 1859; Chevers, op. cit., p. 14.

[2] See article on Diseases of Veins.

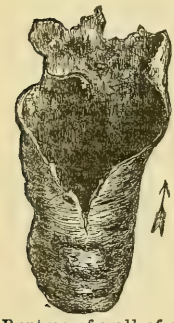
[3] Bouillaud, op. cit.; Bouchut, op. cit., p. 244; Lee, op. cit., case vi.; Humphry, "On the Coagulation of the Blood in the Venous System during Life." Cambridge, Macmillan & Co.

perhaps, of fibrin as yet unreduced to a granular condition.

Such is the material which is prepared in many cases of pyæmia to enter the current of the circulation, and which is supposed to excite the secondary complications by mechanical obstruction of the capillaries, setting up local irritation and impeding function, and so causing actions of an ordinary inflammatory character to become established.

Three points here require a brief notice. (*a*) Do disintegrating clots acquire the characters of true pus? There is no proof that they do. They sometimes contain simple cells which have been regarded as inflammatory products; but pus-cells are not detected, so at least say recent observers. Their statement, however, must be received as offered under the existing views of pus-formation, of which much might be said for which the present is scarcely the place, though attention may be drawn to the revival in some sort of the doctrine, descended from Hunter, and so much insisted upon by Gendrin, that pus-cells are not changed blood-corpuscles, but cells reformed from the disintegrated blood-constituents. (*b*) How does the softened clot-débris find its way into the circulation? First, through some collateral branch connected with the vein where closed by the softening mass; secondly, by rupture of the clot-wall which separates the débris from the circulating blood (Fig. 99), either at its distal extremity, opening into the nearest branch, the clots entangled about the valves preventing their perfect closure, or at its proximal end, the further formation of a clot to confine the débris being usually prevented by the presence of a strong anastomosing blood current. (*c*) Are these softening clots found in all cases of secondary complication? Sometimes their presence is easy of proof, sometimes it may be inferred from the existence of a morbid change with which they are usually associated. Their presence is certainly more constant than that of any other condition with which the secondary affections can reasonably be connected, but it is very apt to be overlooked. A female, for instance,

Fig. 99.[1]



Rupture of wall of a softened clot.

[1] Museum of St. Bartholomew's Hospital, series xiii. Clot from a pulmonary artery, its softened contents discharged through its distal extremity.

died from pyæmia which followed disease of the knee-joint; the vessels of the limb were examined and were healthy, and it was assumed that some other cause must be sought in explanation of the pyæmic symptoms. There existed, however, a bed-sore over the sacral region, and about this, and also in many of the vessels leading to the internal iliac vein, numerous softening clots were discovered, and were, without doubt, the source of the secondary affections.

Bristowe and Savory have pointed out that the embolic theory does not explain cases in which the capillaries of the lungs escape whilst other organs are affected, although in the course of the circulation they should have first been blocked; and this objection is not answered by the suggestion that the fragments may have slipped by the first set of vessels. These cases class rather with those of systemic infection.

As it stands at present the term pyæmia clearly includes, (1) cases in which animal products, such as septic fluids, poison the blood, causing mischief of a typhoid or pyogenic kind, and producing often, but not necessarily, what are known as secondary abscesses; (2) other so-called secondary affections (abscesses) in which the débris of softened clots, and detached portions of fibrin, find their way into the blood, and give rise to mechanical obstruction, and both are modified by predisposing causes in individual cases.[1] It is to be regretted that surgeons have not limited the term pyæmia to the class of secondary deposits traceable to mechanical causes. Now that the term is held to include all cases of septic or puriform infection arising in the course of surgical injuries or diseases, it is loosely named as the cause of death in many cases, and surgeons differ widely in their experiences of a disease which admits of such elasticity of application.

Effusions of pus into serous and synovial cavities may be thus accounted for so far as pyæmia is concerned. Many of them depend upon contiguous irritation, as previously mentioned; and the actual effusions are less frequent than has been sup-

[1] Savory arrives at the following conclusions:

"The causes of the local congestions and suppurations in pyæmia may therefore be thus classified:

"Stasis due to mechanical action. A blockade produced by the impaction of solid particles. . . .

"Stasis due to change in the blood produced by the admixture of morbid fluid. The local effect of blood-poisoning, properly so called.

"Stasis due to a combination of the two above-mentioned causes."—*St. Barthol. Hosp. Reports*, vol. i., p. 139.

posed, cases of suppuration around being sometimes taken for those of pus within the cavity of a joint. But there are cases in which these effusions occur during the later stages of the disease, and, like the pustular affections of the cuticle, indicate extreme modification of the blood. The explanation of such cases must be sought for in common with that of like changes which, first noted by Petit, and now familiar to all physicians, occur in the course of scarlatina and allied diseases.[1]

Opinion must vary as to the *prospect of recovery* from systemic infection; and so much depends upon the previous habits and condition of each patient, that without a knowledge of them it is easy to be wrongly biased. Thus in cases of septic poisoning, as has been already stated, one person recovers from an inoculation of a violent character, whilst another succumbs to one comparatively trivial. But, though we may be doubtful of the result and cautious in opinion at the commencement of the disease, all uncertainty is soon removed as the symptoms incline to convalescence, or acquire the familiar characters of rapid or of protracted sinking. The slowness with which the symptoms are from the first developed may be regarded as, on the whole, a favorable sign; whilst, if there has been great constitutional disturbance before the turning-point is reached, a slow convalescence must be anticipated; or, if the disease has been associated with profuse and exhausting suppuration, surfaces may be left to heal, or diffused abscesses to contract and close, under the burden of which patients sometimes sink.

What is to be said of the prospect of recovery from the secondary complications? Taking those cases in which no doubt has existed of the nature of the disease, is it probable that a fatal result invariably ensues? It is true that some cases are recorded in which patients have recovered, but in few of these is the existence of pyæmia certain. It is probable that a fatal result must generally be anticipated; for all practical surgeons acknowledge that very little chance remains for the patient who, after an operation, is attacked with the symptoms of this disease. This is no matter for surprise if the predisposing conditions are taken into account. But this view of the prognosis, which facts justify our taking, urges most strongly the necessity of attending to prophylactic measures.

The *diagnosis* of these disorders presents no difficulty, and though septic poisoning in many cases has symptoms analogous to typhoid fever, the history of each case will suffice to distinguish between the two. If, indeed, no distinction could be drawn, it would be of little moment, as the two diseases require much the same treatment, and only differ materially in their secondary complications, which are easily recognized, and are at once characteristic of the malady to which they belong. By inquiring, then, into the history of each case, its nature is always evident, nor is it likely to be confused, even when accompanied by pain in the articulations, with diseases so well marked as those of a rheumatic nature, or with ague, despite the occasional intermittence of the rigors. Secondary complications, as they first declare themselves after operations, with rigors and constitutional disturbance, have symptoms in common with many surgical fevers; but their typhoid character is soon declared, and the rapidity of their progress, or the intercurrence of local physical signs, presently remove all doubts as to their nature.

In the *treatment* of systemic infection both local and general measures are required.

Local Remedies.—An excoriation, an ulcer, or a suppurating wound may exist, as has been seen, for the reception of the poison; and, although no satisfactory explanation can be offered of the fact, it must be assumed that wounds may themselves engender septic matter. When a part is poisoned by the bite of a venomous animal, the poison can be removed, or its influence weakened, by the simple operation of sucking the wound before, as is supposed, it has had time to enter into the system by absorption; and, were the act of inoculation capable of such easy recognition, some remedy might, after the same fashion, at once arrest its action. Unfortunately in the majority of cases the first notice of this disease comes from the symptoms of a more or less serious character which ensue. Take the earliest of these, such as pain about an excoriation, with slight duskiness of the surrounding integument; can any measures be recommended to destroy the suspected spot before the septic material has extended its influence to the tissues beyond? Nitrate of silver or the actual cautery has been frequently applied, and even stronger remedies, such as nitric acid, if a greater destruction of tissue is thought desirable, the part so treated being afterwards enveloped in soothing fomentations or emollient poultices, and in certain cases even amputation has been advocated. The prospect of destroying the poison by local measures applied to suppurating wounds is far less than when abrasions or recent wounds have to be dealt with, and therefore all the greater care should be taken of their general management. Their treatment must be as simple as possible, all sources of irritation, as foreign bodies or accumulations of pus, should be removed,

[1] See an interesting case reported in the Med.-Chir. Trans., vol. xxi., p. 148.

and fomentations or water-dressing should be applied. The part should be kept clean by frequent bathing with tepid water; it should be well ventilated, and its position should be arranged so that all lodgements of pus may be prevented. It is possible also that charcoal-poultices, or carbolic acid solutions, may be advantageously employed. Should diffused inflammation supervene, it must be treated after the fashion of phlegmonous erysipelas, and, as its very existence depends upon the feebleness of the patient, it must be remembered that antiphlogistic measures are inadmissible. If the infection has become general, local treatment must be limited to the dressing of the wounds, if any exist, with some simple applications.

General Remedies.—It is always as well to inquire into the habits of each patient before adopting any general treatment, as individual cases require that principles which hold good for all should be variously modified for their special benefit. There can be no question as to the necessity of prompt attention to the various secretory functions. Nausea, if present, should be allayed according to its cause, and the alimentary canal should be cleansed by a dose of calomel and jalap, or by a milder aperient; and this may be done on the mere suspicion of a systemic infection. As soon as the disease becomes declared, the first object in its treatment is to promote, if possible, its elimination, at the same time allaying nervous irritation and supporting the patient's strength.

If the *elimination of the poisons* could be effected, the symptoms would undoubtedly subside; but so little is known of their action, and their nature is so obscure, that it is difficult to suggest remedies for their removal. It would seem as though the system might be relieved by the increased action of the secretory organs, and this view is apparently favored by the congestions which accompany the disease, and by the fluxes which often ensue. The fluxes are, however, often met with when the blood is so greatly altered that it readily parts with its serum, or, together with its coloring matter, is exuded from its vessels, these having probably undergone some previous change in the structure of their walls, which itself determines the flux. It is reasonable notwithstanding to give eliminating remedies a fair trial, so as to encourage secretion from various organs; but they must be tried with caution, lest they add to the prostration which so invariably accompanies the disease. Medicines may be given to promote secretion from the intestinal canal, and saline draughts may be ordered, with the addition of bicarbonate and bitartrate of potash, to increase the renal excretion. The patient should be kept warm, and the action of the skin should be encouraged by diaphoretics; warm-water and even vapor baths, may prove useful in some instances. With such treatment the cases of reported recovery have been conducted to a favorable issue: it has appeared to aid the effort of nature to right the condition of the blood, and might probably be usefully combined with other remedies which should act more directly upon that fluid through the organs of respiration.[1]

The nervous depression also constitutes an important feature of systemic infection, and is not unfrequently combined with irritability and restlessness. Nothing soothes these conditions so well as opium, which, in one form or other, should be given in small and frequently-repeated doses, unless in isolated cases there exist some particular objection to its use. When the patient is kept well under its influence in the manner recommended, it seems to act more efficaciously than when given at irregular times, or at long intervals, or even frequently in the very large doses recommended by some surgeons. Dover's powder is another remedy which may often be usefully employed as a night-dose in addition to the opium. Should *sickness* or *vomiting* supervene, the stomach should be left as quiet as possible, medicine and necessary food being given in the smallest possible quantities, repeated as frequently as occasion requires. This vomiting is often a very troublesome complication; perfect rest is its best treatment, though sometimes it seems to be allayed by doses of chloroform or of dilute hydrocyanic acid, or by the taking of small quantities of ice. *Diarrhœa* seldom calls for interference, as, from the previous remarks, it will be recognized as one of the means by which the system seeks relief, and should rather be encouraged within certain limits, by the administration of mild aperients. If accompanied by exudation of the disorganized blood, it does not admit of arrest by treatment; but if simply profuse, it may sometimes require checking, lest the patient be too much reduced by its persistence.

Disturbance of the circulation is quite a secondary affection, and can only be relieved by elimination of the poison which excites it. Nevertheless, if a patient suffers inconvenience from tumultuous action of the heart, and consequent dyspnœa, the overworked organ should be relieved if possible. Such relief may be found in the fluxes already mentioned, and especially in free excretion from the kidneys, regulated,

[1] Experience shows that no reliance can be placed upon medicines, such as the chlorides or sulphites, which are supposed to act by neutralizing the morbid condition of the blood.

of course, in its production by the state of the urine. Digitalis is also useful by its more direct action upon the heart.

Last, but not least in importance, is *the necessity of supporting* the patient's strength during the progress of the disease. Measures to this end are, in most cases, required from the first onset of the symptoms; indeed it is probable that the patient, if previously under treatment, will be already upon some plan of supporting or tonic remedies. The quantity to be given, and the stimulants to be recommended, vary of necessity in individual cases, and depend so much upon general principles of treatment, that it is needless to consider them more fully; and the same may be said of the precise period at which this treatment ought to commence. Such remedies should be given in small quantities, frequently repeated, and with them should be ordered such light but nutritious food as the stomach ought to bear without being excited to nausea or vomiting. Given with other remedies at an early stage, save in exceptional cases, the action of the stimulants should be carefully watched for in the general symptoms of the patient, and thereby regulated; for the pulse, owing to the condition of circulation kept up by the poison, is a bad index of their efficacy.

If the patient recovers, care will be required during convalescence, for the system is slow in answering to the stimulus of ordinary tonics. Change of scene, dry bracing air, and strengthening medicines, naturally suggest themselves; such remedies as bark, and more especially the various preparations of iron. There is no security against a relapse, and none against a recurrence after a longer interval of a similar or an allied infection, except in the careful after-management of these cases.

In the *treatment* of the *secondary complications* (pyæmia), the *general remedies* are much the same as for the systemic infection; the depression is, however, usually greater, and calls for an earlier and more free administration of stimulants; mercury, depletion, and the like remedies, being altogether inadmissible. The *local measures*, so far as any recognized primary mischief is concerned, have been already mentioned. No local treatment can prevent the formation of secondary abscesses; not even the pressure upon the veins above the local mischief, suggested by Hunter, to bar the entrance of foreign or other matters into the system, by causing obliteration of the canal, nor yet the amputation of the part first diseased, as some surgeons would have us to believe.[1] Even for the relief of the local abscesses, which have occasionally to be punctured, opium is the only remedy on which reliance can be placed, and of course its action is simply palliative. Effusions into joints should be treated by soothing lotions and rest; they are rarely so painful as to call for interference; under any circumstances, all that can be done is to lay the articular cavity open, to allow the escape of pus, and to prevent re-accumulation by placing the part in a position favorable to the escape of fluids.

The little that can be done in the way of treatment when these diseases, more especially the secondary complications, are fairly declared, leads to the question of their prevention; and as this necessarily implies that the cases are brought early under notice, it can only apply to a limited number, and chiefly to those which follow operations. It must suffice to glance at the predisposing conditions which can be usefully dealt with.—*Previous disease.* The essence of preventive treatment lies in the improvement of the general health. The broken-down subjects of disease and starvation are prone to all the troubles which may follow a surgical operation; they require careful preparation before undergoing so serious an affair. They must be strengthened by tonics, such as quinine or iron, and their secretions must be set right by appropriate alteratives; this treatment, too, must be continued for a considerable period; for if the health be much broken, it is slow of taking effect, and its employment for only a few days prior to an operation is of course simply useless. The diet should at the same time be attended to, and persons of intemperate habits should be accustomed to a more healthy mode of living, although in no case should the stimulants be too suddenly withdrawn. Simple as these details appear, the success of an operation often depends upon their observance; in many cases, no doubt, they are unattainable; in some from social circumstances, in others from the rapid progress of a disease which forbids delay; if so, and the operation is indispensable, it has to be performed under unfavorable circumstances. In all cases, the condition of the internal organs must be looked to; the urine should be tested for albumen, and the state of the thorax and of the abdomen should be noted; should any of them be found ailing, knowledge of the fact may enable something to be done to better the patient's prospect.—*Previous restraint.* Under all circumstances the system, if possible, should be accustomed to the new conditions in which it will be placed; and by preparatory rest in bed, the patient should get over the irritation which such confinement often induces. To this Chevers refers,[1] when he draws attention to

[1] See Sédillot, op. cit.

[1] Op. cit., p. 85.

cases in which, although the patients have been taking daily exercise in the open air up to the time of undergoing operations, and subsequently lay in wards which were very free from noxious exhalations, they nevertheless sank in a very few days from pneumonia and other thoracic affections of the most aggravated kind. If this holds good for the inhabitants of crowded dwellings, it does so the more for those accustomed to active country occupations, who are suddenly shut up in the comparatively close and ill-ventilated air of hospitals and sick-rooms.—The *general treatment after operations*, in cases predisposed to these disorders, consists in supporting the strength and in giving a nutritious diet; in surrounding the patient with sufficient and pure air. Opium is also of great service when given in doses sufficient to keep the system quiet and free from irritation; and under the continuance of this influence, reparative processes appear to progress most favorably. Wounds should be kept perfectly at rest, care being taken to promote their early closure; for when this is attained, exhausting suppuration is avoided and the disposition to pyæmia is lessened; they should also be kept clean and free from irritation. To this end they should be cleansed with tepid water applied with new lint; whilst sponges and soiled dressings should be carefully avoided, lest they inoculate the wound with discharges from other sores. Not only is this a probable occurrence, but there is some ground for believing that surgeons or nurses may carry poison from one case to another, so that some caution should be exercised in the examination of wounds, and in the re-employment of instruments, lest the disorder spread amongst patients crowded together, as in the wards of a hospital, and in whom it is easily excited owing to the predisposition induced by the confined air and other circumstances already referred to. *Chloroform* has probably a depressing influence upon the system, in some cases more so than in others; but it may be asserted that there are no cases in which the occurrence of these diseases can be attributed to the effects of its administration. By doing away to a great extent with the shock of an operation, chloroform, it is true, lessens the reaction; but there is no reason for regarding this as an unfavorable influence. [Ether may be used without fear in such cases.]

TETANUS.

By Alfred Poland, Esq.

Revised by J. S. Jewell, M.D.

This disease is generally described as *a powerful and painful spasm of the voluntary muscles, which is long-continued and uncontrollable.* The spasm of the muscles is that of rigid contraction, and from its constancy and non-intermitting character it has been termed *tonic.* These spasms continue without any interval of complete and perfect relaxation, except in the last stage of the disease previous to death; and although violently increased from time to time by sudden and most severe paroxysms, yet they are never for an instant discontinued altogether, so long as the complaint can fairly be said to exist. The spasms are not to be mistaken for those of convulsions, which consist in alternate spasms and relaxations, remitting and intermitting, and often receive the appellation of *clonic.*

Tetanus has been regarded as consisting of several forms and varieties, based upon some peculiarity in its mode of development and subsequent course. In former years it used to be subdivided into classes, according to the predominant affection of certain muscles, and thus varieties have been described,—Trismus, Opisthotonos, Emprosthotonos, and Pleurosthotonos; afterwards it was considered more advisable to arrange it, according to the probable cause,

into *traumatic*, where it arises from injury, and *idiopathic*, where no external or visible cause is apparent. Again, tetanus has been classed according to its intensity, rapidity, and duration, under the denominations of *acute*, *subacute*, and *chronic* tetanus. For practical purposes we may regard the disease in two forms, recollecting at the same time that both are one and the same affection, modified in intensity and in its effects by some peculiar condition: 1st, the *acute form*, which is generally met with after injuries, but may also exist, though more rarely, in the idiopathic variety, and is for the most part fatal; 2d, the *chronic form*, the usual type of idiopathic tetanus, yet occurring in the traumatic variety: this is the form which raises the hopes of the surgeon and physician, as recovery may take place by judicious treatment.

We shall, however, confine ourselves to one description of the disease, viz., the acute form, and reserve for separate consideration such modifications and deviations from the typical affection as offer any special peculiarities.

Premonitory Symptoms.—Although there can be no doubt that, in many instances, there may be certain signs which usher in this complaint, yet these do not differ from the ordinary premonitory symptoms of other diseases, and do not lead us to anticipate its onset: thus we may find an uneasy sensation in the wound, or an additional pain thereof, or the wound may become inflamed and irritable: there may be febrile symptoms and restlessness, languor and debility, loss of appetite, headache, constipation, etc.; still not one of these symptoms is in any way peculiarly and especially associated with the approach of this terrible disease.

The first evidence of tetanus unfortunately and but too truly portrays the unmistakable nature of the disease; the condition of the muscles of the jaw, or the aspect of the patient, at once announces the victim.

Mr. Morgan[1] has given a very graphic, although in parts somewhat exaggerated, description of the onset, progress, and termination of this disease in its acute form, and as it is generally quoted, we have thought it better to transcribe the account given by him, instead of adding another description to the already overstocked number. He writes: "The first *decided* symptoms will almost invariably be an uneasy sensation and stiffness in the muscles of the lower jaw and tongue, which does not, however, in the *first* instance, amount to actual pain, unless the parts are a good deal moved about, and generally about the same time *stiffness is observed in the back of the neck*. Thus the first complaint of your patient will often be, "that he has taken a cold, and is suffering from a *sore throat* and *stiff neck;*" and therefore, unless the friends and attendants are made acquainted with the importance of keeping a strict watch for the occurrence of these symptoms, and the necessity for an immediate application of remedies, they will be attributed to a wrong cause; and thus the disease will be gradually gaining ground till the only hope of safety is gone, for the sole chance of recovery from the use of remedies depends upon their early application. Some have complained of a violent pain under the sternum as a concomitant symptom.

"As the disease proceeds in its course, the patient complains of *difficulty and pain in masticating and swallowing his food;* the lower jaw soon becomes completely fixed and closed, and with every effort to open the mouth, the pain, which is now continued and severe, is increased to agony. In this early stage you will usually find that the muscles connecting the head and neck with the body are affected, and that the concomitant symptoms are languor, debility, and either complete or incomplete bending of the body backwards.

"The next symptom will be a convulsive cramp in all the affected muscles, brought on by any attempt to swallow; and the very idea of being obliged to make such an effort excites an expression of horror and distress in the countenance. Sometimes in the early, and more rarely in the advanced, stage of tetanus, the stomach will be sympathetically affected, and, in consequence of this, nausea and vomiting will occasionally occur.

"The next constant symptom will be a *sudden, violent, and continued pain*, increased at short intervals by spasm extending from the *scrobiculus cordis* to the spine, in the situation of the diaphragm.

"Shortly after this symptom has shown itself, the *abdominal muscles* will be constricted and hardened by tetanic cramp; and the contraction of these parts is so permanent and violent, that, on pressing upon the abdomen, the muscular fibres convey to the hand the sensation of a hard board beneath the skin, rather than that of living animal matter.

"In the course of time all the voluntary muscles partake more or less in the disease. The head is thrown back and fixed by a powerful contraction of the extensor muscles of the neck. The extremities likewise become fixed and rigid. The shoulders are drawn forward by the pectoral and deltoid muscles; and the arms are either stretched out or fixed in a parallel line with the trunk, or drawn across the abdomen. The lower extremities are almost invariably in a straight position, and consequently in a line with the body. But notwithstanding the continued and powerful contraction of muscular fibre in the limbs, it will be found that the wrists and fingers are but little affected; the ankles and toes, however, suffer occasionally from the effects of the disease.

"At this period of the complaint the *countenance* is pale, anxious, and contracted,[1] and is disfigured by the perverted action of the

[1] "A Lecture on Tetanus," 1833

[1] An aged expression of the face. The disfigurement may remain permanent after recovery from the disease; in a case under the author's care, it was still well marked, after a lapse of eleven years.

muscles, producing what is termed 'the tetanic grin' (Risus sardonicus). The spasms now become more violent and more frequent, and during their continuance and immediately after them the respiration is hurried and laborious; but in exceptional cases it may be easy and performed by the abdominal muscles. While the spasmodic paroxysm lasts *the pulse* is generally quick, small, fluttering, and irregular; but during the intervals both the pulse and respiration are comparatively tranquil.

"In some cases the spasm becomes so violent that the assistance of an attendant is necessary, during the paroxysm of cramp, to prevent the patient from being projected out of his bed. In other cases, again, the spasms are less sudden, though equally strong and painful, and consequently, instead of that jerking contraction of the muscles, the body is more gradually raised from the bed, and if the muscles at the back of the neck and trunk and those of the lower extremities are the parts most powerfully affected, then it often happens that the body at intervals is drawn into the form of a bow, and in the recumbent position the occiput and heels rest solely on the bed, whilst the lower limbs and trunk curve upwards to form a complete arch.

"It will frequently happen that, in consequence of the continued contraction of the sphincter muscles of the bladder, retention of urine takes place, and priapism will occasionally occur as a concomitant symptom. (This latter symptom is unusual.)

"The *bowels* are in most cases obstinately constipated, and the large intestines loaded with offensive scybalous matter.

"The *secretion of urine* varies, but it is rarely very profuse.

"Towards the termination of the disease, the torture of the last attack of spasm, and the apprehension of the near approach of another paroxysm, produce an expression of dreadful mental distress and anguish in the countenance. The sufferings are only to be soothed by perfect rest and quietude; the slightest attempt at motion immediately brings on a new attack of spasm; the opening of a door, or the waving of the bed-curtains, will throw the patient into convulsions; and even the sound of that voice which, on other occasions, might have soothed and smoothed the path of anguish and of sorrow to the grave, will now only add increased agony to intense suffering. Every sound, every moving object in the room is fuel added to the fire which is consuming the life of the tortured victim.

"At the close of life the whole face becomes distorted and disfigured, and the larynx forcibly drawn upwards;[1] the spasm in the muscles, depressing the lower jaw, now and then alternates for a moment in severity with that by which their antagonists are affected, and thus for a moment an aperture is left between the jaws through which the tongue is instant lypushed and as instantly crushed and lacerated by the sudden closure of the teeth upon it. If a large portion of the organ should be thus wounded and strangulated, hæmorrhage will immediately follow, and the countenance and even the bed-clothes will be bathed in blood, thus giving additional horror to a scene in which the extremes of mental agony and intense bodily suffering appeared indeed to have done almost their utmost beforehand. (Wound of the cheek or tongue is rare.)

"In some cases the last moments will be comparatively tranquil, for exhaustion and delirium occasionally render the patient alike insensible to pain and to all that mental distress which was previously excited by apprehension and despair; but, in the majority of instances, the torture of a paroxysm of spasm terminates at once the sufferings and the life of a tetanic patient.

"The intellectual faculties remain unimpaired even to the last, and the senses are perfect, but sometimes rendered morbidly acute."

Febrile excitement is not essential, but if present is secondary. Dr. O'Beirne states that he witnessed about 200 cases; but he never saw one accompanied by fever. Profuse perspiration is often observed, and especially during the spasms.

Sleep rarely occurs in acute traumatic tetanus, and then only during a few minutes, or in the intervals between the exacerbations, or when the continued contractions in these intervals are not attended by much pain. In the subacute cases, however, sleep is more frequent, and a more complete relaxation of the muscular contractions takes place; but upon the patient being wakened the full tension of the muscles returns.

The following varieties have been noticed in the characters of the muscular spasms:

1. *Trismus*, or clenching of the teeth from spasm of the muscles of mastication. This is so constant an occurrence in tetanus that the disease has received the special appellation of *locked-jaw*. We must recollect, however, that this is not the sole symptom of the disease, but only one local sign, and may be met with in other affections; this will again be referred to when alluding to the diagnosis of the disease. Towards the decline of tetanus, and where it is attended with extreme exhaustion and prostration, the spasm of these muscles gives way, and the jaw becomes relaxed and drops open.

2. *Opisthotonos*, when the body is bent backwards. This is the most common variety, and is generally noticed in the ordinary descriptions.

3. *Emprosthotonos* is when the body is bent forwards. This is very rare, and has been seldom witnessed. Aretæus has mentioned it, and Larrey has recorded several cases.[1] The muscles on the anterior part of the body are said to be so contracted as

[1] Feebleness of voice often occurs, and is said to be due to the spasmodic interference with the action of the chest, and to the tight shutting of the jaws.

[1] Larrey, in his Mémoires de Chir. Militaire, tom. i., observed that if the wound happened to be in the anterior part of the trunk, and tetanus followed, it was generally in the shape of emprosthotonos. It was actually the most common form in the army of Egypt.

to bend the head upon the chest, to curve the spine anteriorly, and to draw the thighs towards the belly. In very severe cases, the head is brought into contact with the knees, so that the body presents the shape of a ball rather than that of a bow, according to the remark of Aretæus.

4. *Pleurosthotonos* indicates that the body is bent laterally. This is also very rare. It has been observed in acute cases, but more frequently in the chronic forms. In the case of a female aged twenty-four, at Guy's Hospital, it was observed to attack the right side more especially: it was fatal in this instance. Sir G. Blane has published two cases.

Trismus nascentium, tetanus infantum.—New-born infants are subject to tetanus, and offer the same symptoms as are observed in adults. It usually makes its appearance about seven or nine days after birth, but may occur up to the fourteenth day. The progress is, however, more rapid in some, death taking place in ten or thirty hours: the disease is then called acute. In others, life may be prolonged to eight or nine days, and it is then termed subacute. It has been attributed to division of the umbilical cord, and hence considered traumatic; and it has been traced to exposure to currents of air, bad ventilation, and unwholesome nutriment, and hence denominated idiopathic. It is frequent among the Negro races, and has been stated to be the chief cause of depopulation of the Negro infants in the West India isles. At one period, the infants born in the Dublin Lying-in Hospital died of tetanus, within the first fortnight, at a rate of 17 per cent.; but when a better ventilation became established, the mortality was reduced to 5 per cent.

Puerperal tetanus is generally of the acute kind.[1]

There are still some other varieties in the symptoms which require to be considered; but these must be regarded as exceptions to the general rule.

Spasms primarily attacking the muscles of the part injured instead of the muscles of the jaw.—Mr. Morgan relates two cases: a sailor, a patient of Guy's Hospital, received a lacerated wound of the fleshy part of the thumb, occasioned by a splinter of teak-wood, which had transfixed the part. This was forcibly extracted at the time, and the wound healed perfectly. The first symptoms of the disease occurred about two months after the accident, and consisted of a painful neuralgic affection of the muscles of the ball of the thumb, without any appearance of inflammation in the part. He died, and on dissection two pieces of splintered teak were found imbedded in the abductor muscle, and resting upon a branch of the radial nerve. A scholar received a blow of a schoolmaster's cane on the hand. In this instance both pain and spasm commenced in the injured part, and the first true symptom of tetanus was a gradual spasmodic contraction of the flexor muscles of the hand, by which the fingers were drawn into the palm. The cramp subsequently extended to the arm and other parts, and eventually terminated fatally.

Absence of pain.—Sir G. Blane mentions a curious case in which the spasmodic affections were unattended by pain even to the last moment of existence. In this instance, the cramps were accompanied by a tingling and agreeable sensation. The accesses were attended by feelings of pleasure, and a strong tendency to laughter.

Special affections of the muscles of the face and eye.—Of seventy-two cases of tetanus occurring in Guy's Hospital, three are mentioned to have been so attacked, and in two of these the spasms involved the orbicularis palpebrarum, inducing closure of the lids, and simulating ptosis. *The muscles of the eye* are sometimes but not generally affected; when this occurs, the eyeball is fixed and drawn slightly inwards, the patient being unable to direct it towards particular objects. The pupil of the eye varies, being sometimes contracted, and at other times dilated.

Cerebral complications are very rare in tetanus, but may be met with in isolated instances; thus there occurred six cases out of seventy-two admitted into Guy's Hospital: in three cases there was delirium, in two of which it came on towards the close of the disease; but, in the third case, was present before the attack supervened, and entirely subsided directly the tetanus made its appearance: in one there was *coma;* but this was considered to be owing to the large doses of morphia administered.

Epilepsy may form a complication; thus at Guy's Hospital a female, the subject of epilepsy, was attacked with tetanus a few days previous to its expected occurrence; there were screaming and convulsions, and these partook of the character of the periodic epileptic seizures.

Convulsions and screaming were observed in a young female who died of acute tetanus on the sixth day of the attack, following an incision into an inflamed bursa over the knee.

Loss of power over the extremities occurred in two of the Guy's Hospital cases.

Miscellaneous complications.—Tetanus has attacked those laboring under bron-

[1] For cases of puerperal tetanus, see Dub. Quart. Journ., 1865; British Med. Journ., June and September, 1865; Med. Times and Gaz., 1865.

chitis and laryngitis, and a fatal issue has resulted; and it has also been complicated with erysipelas, and with fatal effects. In the case of a man aged sixty-two, the skin of the abdomen was found to be peculiarly shrivelled. In one case the symptoms continued severe until the ninth day, and on the eleventh day a miliary eruption appeared over the whole body, accompanied with succession of spasms and intervals of repose. On the sixteenth day exhaustion and rambling supervened; but on the twenty-second day subsidence of the symptoms took place, and a protracted recovery ensued.

Remission of the symptoms.—This is extremely rare, yet it has been noticed in several instances. Of sixty cases observed in Guy's Hospital, four had this peculiarity: in two of these there was evident relief of the symptoms for thirteen days, although death ultimately ensued from exhaustion; in the other two remission only took place for a very short period, viz., a few days, and was succeeded by more intense symptoms ending fatally. Dupuytren mentions a case in which the disease subsided for twenty-eight days, and then returned after an exposure to cold. M. Duval mentions some curious cases in which the disease assumed the form of anomalous ague, in one of which it was remarked that both sides of the body were never affected by the paroxysm, but regularly alternated in successive fits.

Death may take place in several ways:

During a paroxysm of spasm and convulsions of the heart and muscles of the larynx.—It is not correct, as some affirm, that death in tetanus is due to the extension of spasms to the heart. Mr. Howship thought so, and records a case in point where the heart was found firmly contracted eleven hours after death. In only one out of sixteen cases, observed at Guy's Hospital, was this condition found. In some instances sudden death has occurred whilst being raised in bed; in another during the administration of an enema; in another whilst drinking; and again, in another, immediately after the extraction of a tooth for the purpose of feeding: it has also been observed during efforts at stool. In these cases the deaths were probably due to spasm of the laryngeal muscles.

During an attack of asphyxia and suffocation.—This occurs generally from the foregoing circumstance, viz., spasms of the muscles of respiration. Of forty-six cases in Guy's Hospital, in which the mode of death was noticed, in thirty-two it arose from the two foregoing conditions.

From exhaustion.—This is less frequently observed, although it was noticed in twelve of the forty-six cases at Guy's Hospital.

From accidental circumstances, such as erysipelas, *coma* from overdose of morphia, etc.

The causes of tetanus may be arranged under two heads: 1st, the probably immediate and *exciting* causes; and 2dly, the remote or *predisposing* causes.

I. The exciting causes comprise:

B. *Wounds and injuries. Traumatic tetanus.*—There is scarcely a single lesion which may be said to be exempt from its attack, from the simple blow or contusion to the most severe compound fracture and laceration. It would be a waste of space to enumerate every form of lesion in which it has been found to occur; we shall, however, classify them in the following order: 1, contusions and strains without wound, such as blows by a cane across the nape of the neck or on the palm of the hand, etc.; 2, wounds of the soft parts, embracing simple abrasion of surface, incised, punctured, lacerated, and gunshot wounds; 3, burns and frostbite; 4, fractures and dislocations, simple and compound; 5, minor operations, such as extraction of teeth, cupping, seton, ligature of piles, the accidental inclusion of a nerve in a ligature, incision into an inflamed bursa; 6, major surgical operations, as amputation, castration, excision of the mamma; 7, surgical diseases, such as gangrene, ulcers of the leg, fistula in ano, presence of guinea-worm under the integument, caries of the tibia; 8, incidents in obstetric practice, such as abortion, retained placenta, etc.

The degree of the local injury bears no relation to the severity of the symptoms; thus, a slight contusion may be followed by the most acute tetanus; and, on the other hand, a patient with severe compound fracture may be seized with a mild attack and recover.

The following relative proportions, which the occurrence of tetanus bears to the several surgical lesions, are taken from cases of admission observed at Guy's Hospital during a period of seven years. There were of

Major and minor operations, 1364 cases: tetanus occurred in 1.
Wounds of all varieties, 594 cases: tetanus occurred in 9.
Injuries and contusions, 856 cases: tetanus occurred in 1.
Burns and scalds, 456 cases: tetanus occurred in 3.
Compound fractures, 398 cases: tetanus occurred in 9.
Total number of cases, 3668; tetanus occurred in 23.

Among the large number of total admissions of surgical disease, independent of direct accident, during the above period, only one case was attacked with tetanus; thus showing beyond doubt that its occurrence is rare in the several forms of surgi-

cal disease, and that it is most frequently met with in the more severe varieties of injury and accident, such as compound fractures, burns, and injuries to the fingers and toes.

The situation of the injury has been especially noticed as a source of frequency by some authors. Others, again, declare that the locality of the wound must be considered as almost a matter of indifference. Hennen observed it oftener after wounds of the elbow and knee; others, again, more frequently from injuries of the thumb and great toe. The extremities, however, are much more exposed and liable to injury; hence perhaps the frequency of tetanus from injuries in such situations.

As to the state of the wound at the time when tetanus sets in: some observers, amongst whom is Larrey, attribute the tetanus to a sudden suppression of the discharge of a suppurating surface, the wound presenting a dry surface, or being covered over only with thin serous exudation. Others, again, are of opinion that cicatrization is mostly complete on the accession of tetanus; thus, Travers goes so far as to offer an explanation of this circumstance in the following terms: "In flesh-wounds the period of commencing cicatrization, after the mundifying process is completed, seems to be the most liable to the attack of spasms. It is difficult to disconnect the phenomena of the incipient spasm with the altered condition of the nervous and muscular structure in the healing or newly-cicatrized part. Cicatrization is adhesion and the fastening of parts before free and movable on each other, and its effects would be equivalent to their strangulation or confinement by pressure of any kind, the interruption to their function being the same."

Others maintain that it occurs most frequently in recent wounds; thus John Hunter expresses his opinion: "Tetanus arises also from slight wounds before either inflammation or suppuration comes on; they are generally the most frequent. It is from irritation." But he further on remarks: "When I have seen it from considerable wounds, it was after the inflammatory stage, and when good suppuration was come on."

Tetanus, however, is found to set in at any period and in any state of wound, and there are no grounds for assuming that any one condition is more favorable to the production of tetanus than another.

The interval between the receipt of the injury and the first symptoms of tetanus is termed by some the period of accession or incubation. This varies from a few hours to many days, and must of itself depend, in a great measure, upon a variety of concomitant circumstances, which will be more appropriately considered under the predisposing causes, such as age, constitution, climate, and sex.

It is asserted and generally maintained to be correct, that tetanus, occurring over twenty-two days after the injury has been inflicted, is more likely to be recovered from; and that the more sudden the onset after receipt of the injury, the more surely will the result be fatal; but, at the same time, we must bear in mind that some of the severest and most rapid cases have occurred where an interval of ten days has elapsed.

Of 277 cases, there were,

Previous to the 10th day, 130 cases, of whom 101 died.
From the 10th to the 22d day, 126 cases, of whom 65 died.
Above 22 days, 21 cases, of whom 8 died.

B. *Tetanus arising from causes unconnected with any injury or lesion of surface*, commonly known as *idiopathic tetanus*. This forms the second variety of the exciting causes, and includes exposure to damp and cold, humidity, irritation of worms, terror, sudden suppression of natural discharges, and acute diseases, etc.

Exposure to damp and cold, however, seems to be the main cause of this idiopathic variety; but there cannot be the least doubt that in a great many of the traumatic cases this cause has played an essential part in inducing the disease, and although the majority of such cases are enumerated as traumatic, yet they should constitute an intermediate variety. Among the vicissitudes of temperature as a cause, the following are worthy of note: plunging into a warm bath whilst heated; falling into a river in a state of perspiration, and during the flow of catamenia; sudden change from the heated atmosphere of a ballroom to the external air; in hot countries exposure to the chilly night air and dew; also exposure to the cold and moist breezes from the sea; sleeping in the open air all night in a fit of intoxication; sleeping on the ground after fatiguing marches under a broiling sun; sleeping in confined and ill-ventilated apartments; breathing a contaminated or miasmatous atmosphere. Hennen lays less stress on the agency of cold than on that of air in motion, for all the cases that fell under his own observation had been exposed to a stream of air either hot or cold.

Irritation of worms.—Worms have undoubtedly been discovered in persons dying of tetanus; thus a case is recorded among those occurring at Guy's Hospital. Dr. O'Beirne, in the Dublin Hospital Reports, seems to regard their presence as of considerable effect in the production of the disease; but, long before him, Laurent of Strasburg went so far as to assert, that even in wounded subjects the real cause

was the presence of worms in some part of the alimentary canal. It is probably a very remote and exceptional cause of the disease.

Foreign bodies in the intestines.—Heurteloup relates a case in which the attack was apparently brought on by an accumulation of cherry-stones in the intestines.

Terror.—Dr. Hennen is an authority as to terror being the immediate antecedent of the disease.

Intense anxiety of mind is quoted by Willan as a cause.

Sudden suppression of the secretions and excretions has been mentioned. Fournier Pascay relates the case of a woman who, while laboring under a gastric fever and in a state of perspiration, exposed herself at an open casement to the north wind, causing sudden suppression of the perspiration.

The suppression of the lochia, and the suppression of acute diseases, such as variola, typhus, and gastric inflammation, have also been enumerated.

II. The predisposing causes, although remote, must necessarily be taken into consideration.

Age.—Tetanus occurs at every period of life.

The peculiar affection in young infants termed *trismus nascentium* has been already alluded to. It is principally seen in the tropics, but has been occasionally met with in Europe. It occurs within the first two weeks after birth, and is supposed to depend upon irritation of the primæ viæ by meconium, worms, unnatural secretion, etc., or on a morbid condition of the umbilical fossa. This has been mentioned before, and will not come under the present consideration.

Of regular tetanus, the youngest case on record is twenty-two months, and the oldest seventy-five years of age. Of 449 cases, there were

Under 10 years of age, 29 cases.
Between 10 and 30 years of age, 261, or nearly 60 per cent.
Between 30 and 50 years of age, 122.
Over 50 years of age, 37 cases.

Sex.—The ancients considered females to be more frequently affected, but less severely, than males. This does not accord with the experience derived from the returns at Guy's Hospital: for out of 72 cases of this disease, 12 occurred in females, being 16.66 per cent., and all were fatal; 60 attacked males, bearing an average of 5 of the latter to one of the former.

Taking a more extensive general average, deduced from 449 collected cases, it appears that males are more frequently attacked in a ratio of about 7½ to one female.

Constitution, habits, previous health, etc.—Is there any peculiarity in the *state of the constitution?* Hunter seemed to think so; he says: "But everything relative to lock-jaw does not arise from irritation of the wound itself, neither from inflammation nor symptomatic fever; for in such states the constitution is not disposed to it. It arises from an irritable habit, which may be increased or produced by irritation, but not such as is capable of producing inflammation. There must be a disposition for the disease; thus, madness is produced from the slightest causes when the mind is predisposed; so it is in agues and fevers, the constitution being particularly predisposed at the time to such diseases."

Sufficient attention has not been paid to this subject to insure any satisfactory conclusion; it appears that the very quiet and cheerful, the very irritable and excitable, the strumous and fair, are alike equally liable, and in each is the disease alike equally fatal.

Condition of body.—Tetanus likewise attacks the healthy as well as the unhealthy, the emaciated as well as the robust and well-developed, the spare as well as the muscular. This does not correspond with John Hunter's remarks, viz., "That those most susceptible to the disease are of sickly and weak frames, and of suspicious minds, and not of strong and robust ones."

Habits of life.—There is much difficulty in arriving at any definite conclusion concerning this point; it has, however, attacked the temperate as well as the intemperate, and the dissipated as well as those who have lived low. Of sixteen cases recorded at Guy's, seven were temperate, and seven intemperate and dissipated, and both bore an equal ratio, as in both there were two recoveries and five deaths. These returns are, however, too meagre for any general conclusion.

Hygienic causes.—Dr. Dickson[1] remarks: "I trust I am, therefore, justified in inferring that to the improvements in the medical and surgical treatment of wounds, in *cleanliness* and *ventilation*, avoiding at the same time *exposure to currents of cold air*, or sudden changes of temperature; in fine, to *superior diet* and *accommodation*, but particularly to the greater attention paid to the state of the bowels, may be attributed the great infrequency of tetanus of late in the West Indies, when compared with former wars."

Races and climate.—Europeans are said to be peculiarly exempt from the disease, whether in their own country or in India. There is much greater liability of the Negro race to every form of tetanus or trismus than of the white race. Mr. Peat, in his

[1] Med.-Chir. Trans., vol. vii., p. 465.

essay on tetanus in the East Indies, gives the following percentage of its occurrence among the various castes, viz.: Hindoos 1.63 per cent., Mussulmans 1.09 per cent., Parsees 1.005 per cent., and Christians 0.75 per cent. Natives of warm climates are greatly susceptible. "Is this," Mr. Travers observes, "owing to their being of a more relaxed fibre and greater susceptibility of impression both external and internal; or, in other words, that less resistance is opposed to morbid action, and that in them the disease runs its course with greater vehemence and rapidity than in those of temperate regions?" John Hunter remarks, "that climate seems the first of the predisposing causes, and that which can probably produce it without any other causes. In warm climates it is most frequent. The cramp is most frequent in warm climates, and also in bed; fits also are more frequent in bed, for warmth seems to have a peculiar effect in producing a particular disposition in the nerves; and when there is an immediate slight cause, such diseases readily take place; nay, some are disposed to such action without any immediate cause, which probably arises from climate, joined with a very strong natural predisposition."

Influence of season in the production of tetanus.—Respecting the separate months of the year in which it occurs, little can be gathered: it seems to be as frequent in one month as another; so also in respect to the seasons of the year, for it is found to be developed in the cold, temperate, and warm months in an equal ratio. The same results are observed in the cases occurring in the East Indies. The influence of the seasons has no effect on the mortality in tetanus.[1]

Occurrence of tetanus after naval and military engagements.—Space will not allow us to enter into this question, as it will be duly considered under military surgery.

Diagnosis.—There occurs sometimes a peculiar affection about the neighborhood of the muscles of the lower jaw, which is attended with spasms, and causes contraction of those muscles resembling very much that of locked-jaw. We must not, however, mistake these purely local diseases, inducing trismus, for the actual disease itself; in all the spurious forms the contraction of the muscular fibre, although constant, is never increased by painful and distressing paroxysms of spasm; and generally, if the exciting cause be removed at an early period, the complaint will disappear. This is often observed in diseases of the alveoli from carious teeth, in ulceration of the gums and mucous membrane of the mouth, etc.; also in children during the period of dentition.

Tetanus may be taken for hydrophobia, in consequence of the spasms in tetanus now and then affecting the muscles of deglutition, inducing a fear of swallowing from its exciting spasmodic action, and giving rise to a dread of fluids. We will offer the leading symptoms of the two diseases in contrast with each other in the following somewhat artificial table:[2]

Tetanus.	Hydrophobia.
Spasm of muscles more continued; less remitting, and never intermitting. Constant rigidity of the muscles of the jaw, becoming gradually fixed and closed; *tonic* spasm.	Spasm of muscles of brief duration; if not voluntary, at least temporary, and will cease to exist during intervals of rest and quietude, the jaw being relaxed, and opening and shutting readily. The spasms are *clonic*.
The cause is exposure to cold or wound, rarely from the bite of an animal, and it generally occurs soon after the injury.	Cause, the bite of a rabid animal, and it rarely appears before the thirtieth day.
The bite of a tetanic animal does not produce tetanus.	The bite of hydrophobic animals must have communicated the disease when it exists.
Countenance, tetanic: drawing up of the nose; wrinkling of the forehead; angles of the mouth drawn towards the cheek-bone, presenting a frightful risus sardonicus. There is an expression of pain, but the eyes are natural.	Countenance, hydrophobic: an expression of excitement, fearful distress, and peculiar restlessness, never to be forgotten; occasionally frightfully convulsed; eyes bright and glistening, but at times suffused.

[1] For an extensive investigation of this point, see Guy's Hospital Reports, Ser. iii., vol. iii.

[2] In Dr. Ogle's collection of cases of tetanus, occurring at St. George's Hospital, he mentions "Case 5 as one of combined tetanus and hydrophobia." See British and For. Med. Review, October, 1868, p. 485. He remarks: "This case is one which seems, to a certain degree, to link together all the three forms of disease—hydrophobia, tetanus, and epilepsy—under one common pathological classification. Given, excessive irritability of the common spinal centre, arising from agents acting either centrally or peripherally through the centripetal nerves, we have resulting from the application of any suitable exciting stimulus an irritation, motor action, or spasm, which may either be of the general muscular system as in epilepsy; or of particular regions, as those of the jaw, neck, throat or back, as in tetanus; or more especially of the throat and pharynx, as in the present case of hydrophobia, the spinal derangement being attended by cerebral disturbance, as in the present instance, with mental delusion and even mania."

Tetanus.	Hydrophobia.
No great thirst, and in general no great aversion to fluids administered in small quantities; rarely any discharge of saliva.	Thirst and aversion to fluids characteristic; even the sight or noise of fluids induces paroxysms; with frequent and viscid discharges of saliva; efforts to disengage it inducing barking and vomiting.
Vomiting and gastric pains rare.	Vomiting and gastric pains general.
Mind generally clear to the last.	Mind subject to rabid impulses and numberless deviations, passing to delirium.
Recovery in idiopathic forms.	No authentic case of recovery.
	Intolerant sensibility of surface and organs of sense.

Idiopathic tetanus has been mistaken for rheumatism, and treated accordingly. Both affections have as their exciting cause exposure to cold and moisture upon the body of a person previously heated, perspiring, and fatigued; and although the symptoms in both, at first, are those of stiffness of the muscles of the back of the neck and other parts of the body, yet they differ in that the one consists of a chronic and slow affection of the muscular, tendinous, and ligamentous structures, while the other confines itself to a spasmodic affection of the muscular system, influenced probably through the medium of the nervous system. However, in two of the Guy's Hospital cases, previous to admission the tetanic symptoms were treated for, and supposed to be, rheumatism.

In a temperate climate, a sudden accession of tetanic symptoms of great severity and running their course rapidly, in a person who has received no local injury, nor been exposed to cold and damp, would create a strong suspicion of poisoning. Thus there are some vegetable poisons which produce almost every symptom of tetanus, as observed either in animals inoculated therewith, or in persons who have unfortunately swallowed the poisons. *Chetik*, a poison prepared from the juice of a large twining shrub, a species of strychnos, produces artificial tetanus.

Strychnia, however, is the poison with which we are most familiarly acquainted, as bearing the closest analogy in its symptoms and effects with those of tetanus. The symptoms produced in animals are general uneasiness, convulsions of a tetanic kind, muscular rigidity, arching back of the head and neck, violent stretching of the legs, and spasms brought on by the slightest touch like a galvanic shock. The symptoms, as it affects man, are agitation, trembling, tetanic convulsions, spine and neck bowed, arms stretched out, hands clenched; the stiffness when once set in never entirely disappearing; recurrence of first paroxysms and reappearance of jerking rigidity; retraction of muscles of mouth and face; the countenance suffused and red, and the pupils dilated. The patient can open the mouth and swallow; there is no locked-jaw, but spasm of the respiratory muscles; terror of suffocation; laryngismus early, sudden, and intense; consciousness retained to the last; senses unnaturally acute; calmness. The time of acting is, in small doses, half an hour to an hour; in large doses, about ten minutes. In large doses, death ensues in a quarter of an hour; in small doses, from half an hour to an hour.

In the celebrated trial of Palmer for poisoning a man named Cook by means of strychnia, it was argued by the defence that the deceased, Cook, died of tetanus from natural causes, and not from any poisoning by strychnia, and hence arose a question as to the diagnosis of the symptoms of tetanus from those of strychnia.[1]

The following are the facts of Cook's case: He was comparatively well up to a certain night, when about eleven o'clock he took some pills, and in three hours he was seized with great agony, and shrieked dreadfully, calling out "murder." He had rigid and cold extremities, the eyes starting, and the whole body convulsed; he was gasping for breath, but was perfectly conscious. There was a gradual subsidence of these symptoms, and he fell into a state of repose and sleep, the attack having lasted three hours. On the following day he was comfortable and conversed rationally, and was improving, having got up and sat in his chair and laughed and joked. At eleven o'clock that night he again took pills, and in an hour afterwards he complained of stiffness of the muscles of the neck; the head and neck became unnaturally bent back, and he screamed and became dreadfully convulsed, crying out, "Raise me up; I shall be suffocated." The convulsions lasted from five to ten minutes, and affected the whole body, so that it was bowed back. It was impossible to raise him on account of the extreme rigidity. He was quite sensible; the action of the heart slowly weakened and ceased gradually. The second attack lasted not more than fifteen minutes from its commencement to the termination in death.

[1] For a full detail of the trial and the diagnosis of poisoning by strychnia, see Dr. Taylor's Essay in the Guy's Hospital Reports for 1856, Series iii., vol. ii., p. 269 *et seq.*

It was argued that the disease was not tetanus, for in the latter affection the symptoms commence in a mild form and then become stronger; it is gradual, continuous, and always progressive, and there is never a total subsidence of symptoms. Again, tetanus rarely runs its course in less than two or three days, oftener longer; and it never lasts for a few minutes and then subsides, to come on again in twenty-four hours. In tetanus from poisoning there are remissions or intervals of relaxation. How far these arguments hold good may be judged of by the perusal of the foregoing details of the varieties in the symptoms of tetanus.[1]

Hysteria, combined with spasm, called hysterical tetanus, occurs in females. There is no instance of a fatal termination of this affection. The representation is often so faithful, that many instances of reputed examples of successful treatment of tetanus have been merely conquest over hysterical spasms.

Dr. Copland remarks: "In females trismus or subacute tetanus may assume an hysterical character, or hysterical symptoms may be associated with the tetanic, the disease being really tetanus and occasioned by an injury. Of this association I had a very remarkable instance many years ago in a cook in my own family. In hysteria, the spasms and convulsions are seldom accompanied with unconsciousness, or if they be so attended, the loss of sensation is incomplete and supervenes gradually; again, the spasmodic or muscular contractions are subordinate phenomena, and of comparatively short duration."

Epileptic convulsions are attended always with entire loss of consciousness, and hence are distinct from the convulsions of tetanus. This symptom often precedes the spasmodic attack; the muscles of respiration are early affected, and cerebral congestion and imperfect oxygenation of the blood result.

Apoplexy never produces tetanic convulsions. However, Dr. Copland remarks one form, "convulsive apoplexy," where the membranes have become involved, giving rise to tetanic rigidity of the muscles, more particularly those of the neck or limbs, with various convulsive movements.

Morphia sometimes produces convulsions; but these are of an epileptic character, and long in their development.

The advantage to be gained by dividing tetanus into acute or traumatic, and chronic or idiopathic, has been much dwelt upon as assisting in guiding us in our prognosis; this may be illustrated from the following quotations: Dr. O'Beirne witnessed 200 cases of traumatic tetanus in the Peninsula, not one of which recovered. Hennen confesses that he never saw a case of "acute symptomatic tetanus" recover. Dr. Dickson found all curative measures followed by unqualified disappointment. Mr. Morgan says, "I have never seen or heard of an instance of recovery from acute tetanus."

A writer in the Edinburgh Journal, vol. xv., says, "that the idiopathic disease is a far milder and more tractable affection; and this is a fact well known to every planter in the West Indies, who never considers his negroes as safe when the disease supervenes on a wound, but is frequently successful in alleviating the idiopathic species."

Some author observes, that if within forty-eight hours the disease runs a rapid course, it will be fatal; but if it be not fully developed until the ninth or tenth day, there may be a favorable termination.

Parry attempted to found a prognosis upon the state of the pulse; he says: "If in an adult the pulse, by the fourth or fifth day, does not reach 100 or perhaps 110 beats in a minute, I believe the patient almost always recovers; if, on the other hand, the pulse on the first day is 120 or more in a minute, few instances will, I apprehend, be found in which he will not die."

Larrey formed an opinion, that perspirations in certain parts, as the chest and abdomen, were critical, while those beginning on the head and extremities were symptomatic only.

Recorded cases are not to be taken as evidence, inasmuch as often only successful cases are mentioned, and deaths passed by as a matter of course.

In acute traumatic cases the prognosis is most unfavorable, and there is scarcely a well-authenticated instance of recovery on record.

In subacute cases of the traumatic variety recovery does sometimes take place, and especially when there is a long interval between the injury and its accession, and where the symptoms set in mild and pursue a slow course, gradually advancing in extent and severity.

In the idiopathic variety, where it does not assume an acute and rapid form, the prognosis is for the most part favorable, and we may always hope for a chance of recovery.

Taking all forms together, in a fair average number of cases the proportion seems to be $7\frac{1}{2}$ deaths to one recovery.

The duration of the disease will be

[1] An interesting case of poisoning by strychnia is reported in the Guy's Hospital Reports for 1868, p. 265. In this case the diagnosis was mainly due to the intermittent paroxysms of spasm, and the lad crying out before each spasmodic convulsion, "It is coming on! It is coming on!"

gathered from the following record of 327 fatal cases:

Within 2 days, ...	79	cases fatal.
From 2 to 5 days, . . .	104	" "
From 5 to 10 days, . . .	90	" "
From 10 to 22 days, . . .	43	" "
Above 22 days, ...	11	" "

Thus the mortality up to the fifth day is equal to, or even higher than, all the remaining cases included. The most rapid death has been in from four to five hours, and the longest duration on record, in a fatal case, is thirty-nine days.

This return will considerably modify the statement generally made, viz., that if tetanus continue over a period of twenty-two days, a favorable issue is to be expected, and recovery almost certain.

The post-mortem appearances are vague and unsatisfactory in the extreme, and it is difficult to decide whether the actual condition observed is virtually a morbid lesion essential to the disease, or an alteration due to other circumstances, such as the mode of dying, or a mere cadaveric alteration. The late Mr. Wilkinson King, of Guy's Hospital, used to remark at the post-mortem table, whenever there was an examination of a case of death from tetanus: "Gentlemen, we will now proceed to give you a demonstration of a case of healthy anatomy, for there will be no visible morbid appearance, otherwise than congestion of the organs in various degrees, which are owing to accidental circumstances."

We shall, however, cursorily survey the more prominent conditions that are met with.

The body is usually found rigid, and the muscles firm and contracted, and occasionally ruptured, but in some there is no rigidity at all.

The nerves at the seat of the wound may be found inflamed, injected, irritated, lacerated or punctured; yet in other cases perfectly healthy and uninjured; and in one case the divided nerve had reunited and was not inflamed.

The brain has been found to be healthy, firm, congested, darker than natural, pinkish, etc.

The medulla oblongata has been likewise found in a healthy or congested state; but some observers have noticed a change in the density and specific gravity of different portions of the spinal cord. The specific gravity was found increased throughout, and generally about the region of the cord which was in immediate communication with the nerves of the wounded parts. In the idiopathic variety this change was found throughout the whole cord. Dr. Copland is rather in favor of post-mortem evidences of morbid change in the spinal cord, medulla oblongata, and membranes. He says: "These changes are rarely altogether absent when the inspection is made twenty-four hours after death; and in no inspection which I have witnessed have inflammatory appearances in one or other of these parts been wanting."

Lockhart Clarke, in his communication "On the Pathology of Tetanus," in vol. xlviii. of the Medico-Chir. Trans., observes that "in six cases the spinal cord exhibited lesions of structure of different kinds, and frequently of surprising extent. It seems to consist precisely of disintegration and softening of a portion of the gray substance of the cord, which appeared in certain parts to be in a state of solution. The fluid thus formed, however, is at first more or less granular, holding in suspension the fragments and particles of the disintegrated tissue, but in many places it is perfectly pellucid."

He asks whether the structural lesions and disintegration of tissue are the effects of the functional excitement of the cord manifested in the tetanic spasm? or are they the cause of the spasms? He negatives the former question, and as to the latter he states that they are not the direct or sole cause, since in those cases of paralysis in which similar lesions exist they do not give rise to tetanic spasms or convulsions.

He believes that the lesions depend on the conjoint operation of injury of the peripheral nerves with hyperæmia and a morbid state of the bloodvessels of the cord, and the resulting exudations and disintegrations.

Dr. Dickinson, in vol. li. of the Med.-Chir. Trans., p. 265 *et seq.*, has given a very accurate description of the spinal cord in a case of traumatic tetanus in a man æt. 25, who died in 18½ hours: "The cord presented three remarkable enlargements, one in the cervical and two in the lumbar region. The morbid changes were: 1. A general intense injection of the cord, with dilatation of the bloodvessels in the gray matter more than in the white, and in the left posterior horn more than in the rest of the gray matter; 2. A structureless transparent exudation had been poured out around the bloodvessels in many situations, and by its forcible intrusion into the tissue had torn the cord in many situations, and had been the chief cause of the extended swellings by the displacement it occasioned; 3. There were certain circumscribed changes in the white columns."

The figures on the accompanying Plate show fully the appearances enumerated in the above remarks.

The sympathetic system has been thoroughly examined; in some it was found healthy, and in others slightly injected. Dr. Copland, in 1822, suggested it to be the

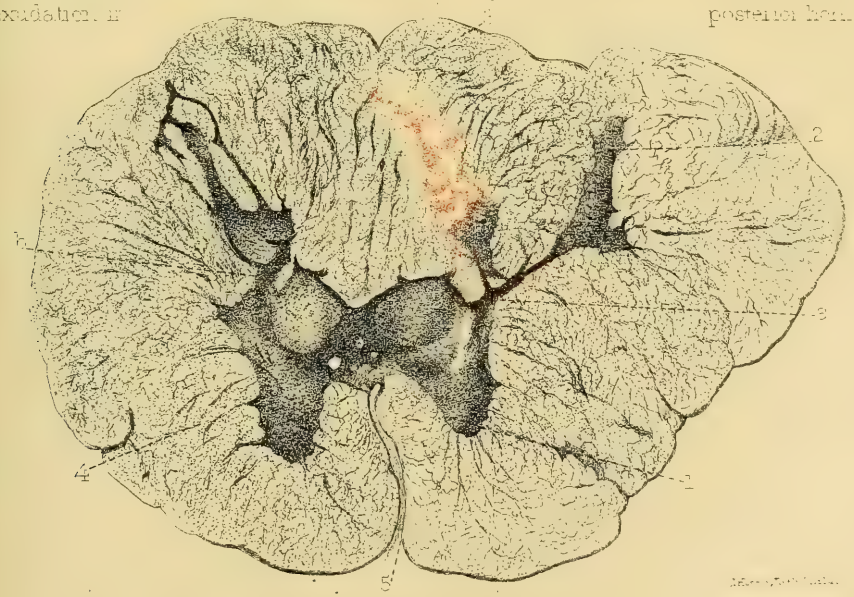
Plate IX.

Fig 1

a Central gray matter reduced to a state of fluid 8 granular disintegration

Fig 2.

a Extravasation in posterior white columns, b posterior horn, the latter presenting two parts, & the lateral part of the corpus striatum [illegible] exudation. [illegible] posterior horn



1 Anterior horn of gray matter. [illegible] horn of gray matter
3 Posterior white columns. 4 Anterior [illegible]
7 Anterior median fissure [illegible]

seat or pathological cause of tetanus; but, as he says, "it must not be overlooked that the ganglia are often very vascular even in health."

The blood is generally found uncoagulated; but in other instances the blood in the heart has been found firmly coagulated, the coagula extending up the arteries and decolorized. There has been no satisfactory examination of the state of the blood, either pathologically or chemically.

Much stress has been laid on the state of the heart, as a means of diagnosis of death from tetanus; but it may assume every possible condition, and is generally only an indication of the mode of death of the individual.

In one case, that of a boy, æt. 11, who died of acute tetanus, the voluntary muscular fibre under the microscope was found very granular, resembling that of the heart undergoing degeneration; otherwise, in the majority of cases, no change has been found in the muscles.

The lungs, larynx, and alimentary canal present no other appearances but what are due to accidental causes and the modes of dying.

From the foregoing remarks on the morbid anatomy, it must be understood that the pathology is still involved in great obscurity. Some affirm tetanus to be an irritation of a peculiar kind, and affecting the excito-motory apparatus; that the irritating cause may be eccentric at the extremity of, or in the course of the afferent spinal nerve, or it may be centric within the spinal canal itself. Some consider it to be an exaltation of the polarity of the cord and medulla. Others, again, maintain it to be identical with inflammation of the spinal cord and medulla oblongata, and adduce cases of inflammation of such structures as inducing symptoms of tetanus.

It has been suggested that it is due to a morbid condition of the blood, inasmuch as it resembles in some respects those diseases which are produced by poisonous agents, as strychnine, hydrophobia, the poison of woorara, etc.

Dr. B. W. Richardson, in the *Trans. of the Epidem Soc. of London*, vol. i., p. 28, on the theory of zymosis, refers to the question of tetanus as belonging to the zymotici. "In this disease, the poison, in my opinion, is first developed in the wound as a result of decomposition. Thence carried into the circulation, the new substance, without any necessary increase of its own parts, excites a zymosis, ending in the production of an alkaloidal or alkaline body, which has all the power of exciting the symptoms of spasm as much as strychnine itself."

The reviewer of the article "Tetanus" in Reynolds's *System of Medicine*, in the *British and Foreign Med.-Chir. Review*, vol. xlii., p. 297, says: "The author does not attempt to trace any connection between the acknowledged causes, cold and damp and wounds, and the production of such a fearful consequence in only a few cases." "With regard to its relations to hydrophobia and analogy of the latter to that of snake-bites, may not the connecting link between chilled wounds and spasmodic paroxysms be an animal poison generated in the wound during the process of healing? And being an animal poison, therefore poisonous in extremely minute doses? And being an animal poison, therefore latent in the system for long periods? And being an animal poison, therefore specially fatal to the nervous system? The greater tendency of punctured and closed wounds to cause tetanus is very suggestive of the needle-like serpent's fang, and the frequent triviality of the dog's bite, which are the more deadly the less blood flows."

Dr. Copland justly observes:[1] "If the difficulty of ascertaining pathological conditions, upon which all rational indications of cure should be based, be so great in this malady as not to have hitherto been overcome, can it be a matter of surprise that the means which have been resorted to, both by physicians and by surgeons, in its treatment, have been most opposite in their effects, the most different in their natures, and in every respect most empirical and uncertain? In this state of our knowledge, it would be better to leave nature to her unaided efforts, to observe closely and accurately what is the true procession of changes and of their manifestations, and to ascertain the seats and the extent of lesion, as soon after death as may be attempted with propriety."

It will be well, however, shortly to enumerate the several methods of treatment that have been adopted and recommended. Each and all have had their advocates, inasmuch as recovery has taken place after their use, and the disease has been considered to be checked in consequence. It is questionable in the extreme, as to the agency and potency of remedies successfully employed in isolated and rare instances, when these same are utterly powerless in the majority of other cases so treated. Of the *local treatment* which has been had recourse to, the following may be enumerated: Incising and laying open the original wound, and removing all extraneous and irritating substances; amputation of the limb; division of the nerves at or about the seat of the wound; the local application of numerous counter-irritants,[2] sedatives, antispasmodics, mercurials, etc.; the application of leeches, cold, aconitina, belladonna, etc., to the spine; various topical remedies to the abdomen and region of the diaphragm; warm, cold, and shower baths; electricity and galvanism.

The constitutional treatment.—Almost

[1] Art. "Tetanus," Dict. Pract. Med.

[2] The application of blisters to excite a renewal of the discharge in the wound. Subcutaneous injections of atropine and other powerful remedies have been tried and found useful.

every internal remedy has been successively tried, and no one individual medicine has been singled out as an appropriate means of cure: thus antiphlogistics, including bloodletting, purgatives, calomel, antimony, colchicum, etc., have been extensively used; alteratives in the shape of the varied preparations of mercury, large doses of fixed alkalies, solutions of arsenic, etc.; diuretics, in the form of tincture of cantharides, oil or spirits of turpentine, given in frequent and large doses, so as to irritate the urinary passages or to occasion bloody urine; sedatives, such as digitalis, tobacco, nicotina, hydrocyanic acid, aconitina;[1] anodynes and narcotics, as opium, morphia, belladonna, colchicum, cannabis indica, ether and chloroform internally and by inhalation; stimulants and antispasmodics, including musk, ammoniacum, camphor, turpentine, assafœtida, castor, wine and other stimulants; tonics, such as quinine, bark, strychnia, iron, zinc, etc.; hygienics and dietetics, as support, milk-diet, etc.; injections into the veins of solutions of opium, stramonium, etc.; tracheotomy and laryngotomy. The Calabar bean in sufficient doses to paralyze the voluntary muscles has been attended with great success,[2] although it has, on the other hand, failed very frequently. Although there is no specific remedy that can be relied upon, yet inasmuch as some remarkable recoveries have taken place from the use of certain medicines, we should at once select one of these well-recognized agents and fully carry out the treatment with energy, whether it be the use of chloroform, the administration of the tincture of aconite, the Calabar bean, quinine, morphia, etc., the hypodermic injection, or the application of curara.

We do not intend to offer any remarks on the foregoing remedies, but merely add that we can hardly call the above medicines administered, even although attended with recovery, "remedies;" they appear, for the most part, to have little or no specific action in the control of the disease. Those remedies which have had a more direct influence have been such as have rendered the paroxysms less severe, and more enabled the patient to resist the exhaustion caused by spasmodic action. We must recollect that tetanus runs a certain course; it has its period of accession, its height and intense activity, and its gradual decline. It often kills by exhaustion during its decline. Nothing seems to check its regular course; there is no control over its unvarying and too often fatal career: it will have its sway. All we can do is to enable our patient to weather out the storm by giving him as much strength as possible, and not adding fuel to the fire by all sorts of applications and internal remedies which have over and over again signally failed. If we can help our patient on, one day after another, we gain much; constant watching and constant attention are required, by night as well as by day; an unflinching perseverance on the part of the sufferer in carrying out these views; besides the avoidance of all causes of excitement, and more especially the cold air or winds; taking care to preserve a uniform temperature as much as possible.

The following apposite opinions are here quoted:

John Hunter thus sums up his views on the treatment of tetanus:[1] "All the antispasmodics have been given, but without apparent success; opium has kept its ground the longest, but with little reason, as it only quiets; but from some patients having got well under its use, its name has been raised; I have tried it, both in large and small doses, though always unsuccessfully. I think medicines have no power without they produce some visible effect. Opium never removes the cause, though it will prevent the effects; it cures spasms and removes pain, but it does not remove the cause. It often does good, by not allowing the symptoms to do harm to the constitution. The first appearance of a cure is a recovery of strength, as weakness is a predisposing cause; and the first indication should be to strengthen the system. I know of no internal medicine."

Again he remarks, when treating of constitutional diseases from local irritation:[2] "As these diseases which I have brought into this class are of such various kinds, each must be taken up apart, and treated accordingly; but they are such as yield very little to medicine, for in some the constitutional disease is formed, and does not require the presence of the local disease to keep it up, as in tetanus; and in others, the local disease being still in force, it is not to be expected that the constitutional affection is to be entirely relieved, although in some degree it may. In those which form a regular constitutional disease, such as an ague, although the local disease may still exist in full force, yet some relief may be expected; the bark is to be administered, although not with a view to cure, as the immediate cause still exists; but bark will in some lessen that susceptibility in the constitution, and may cure, at least for

[1] See cases of recovery by Fleming's tincture of aconite, Brit. and For. Med.-Chir. Review, 1859, vol. xxiii., p. 486.

[2] See Remarks and Cases by Dr. E. Watson, Lancet, March 2, 1867.

[1] Hunter's Works, by Palmer, vol. i., p. 588.

[2] Hunter's Works, by Palmer, vol. iii., p. 437.

a time, as I have seen in agues arising from fistula in perineo."

Travers observes:[1] "Now the treatment of tetanus admits of the employment of two classes of remedies, relaxants and tonics. They are in no degree incompatible, but common sense would lead us to endeavor first to calm a wrong action, and having succeeded in calming it, then to apply our tonic for the restitution and preservation of the right one. Perhaps the tonic may be the calming power we ought to employ in a case so rapidly destructive to life as the really acute tetanus; but our limited experience does not warrant the conclusion."

We cannot finish this article without adverting to the recent attempts at cure by means of the woorara poison. Mr. Morgan, in his work on tetanus, offered the following suggestion as to a means of cure in this disease. He writes: "There is a close analogy between tetanus and some other spasmodic affections produced by the inoculation of poisons. Almost every symptom of tetanus may be produced in animals by a poisoned wound from chetik, a species of strychnos. It occurred to me, that if I could obtain an equally active poison which produced diametrically opposite effects, I might be able to control the effects of the one by the operation of the other (*contraria contrariis*). The ticunas or wourali [woorara] was found to have this effect, and I could readily control the severity of the spasms and prolong life by the subsequent inoculation therewith. In more than one case I have perfectly restored the animal to health by bringing this antidote into operation as soon as the first effects of the chetik were observed, and regulating its after-consequences by partially or altogether cutting off from time to time, by means of a ligature, all nervous commuication between the wound into which it was inserted and the brain. In all cases I took care to insert a quantity of tetanic poison more than sufficient to destroy life, provided no remedies had been used." But it is only within the last two years that this plan has been carried into effect. An Italian surgeon was the first to use woorara: he employed it in three instances, applying the poison in solution to the wounded part, and, where no wound was present, to a raw surface artificially produced by blisters. In two of his cases the tetanus was acute and traumatic, but both died; in the third case the disease was chronic, and recovery ensued. In Paris, likewise, three cases have been experimented on, and with the same result. So also in London, two acute, and one chronic or subacute case, have been treated by woorara, and recovery only effected in the latter case. Thus, of nine cases in which woorara has been employed, six were acute, and terminated fatally, and three were chronic or subacute cases, which recovered. Now this is not at all satisfactory; for chronic or subacute tetanus is a recoverable disease; not so acute tetanus, and it is here that a remedy is anxiously sought for. Woorara has at present not fulfilled its purpose. Curara as a cure has been thoroughly investigated, and cases of recovery recorded by Demme.[1] Dr. Harley attributes its value to its peculiar power of paralyzing the motory much sooner than the sensory nerves. Its action in tetanus is to allay the spasm; to keep the spasms from killing the patient by their violence, until the morbid state calling them into play has exhausted itself.

[In the additions to the article on tetanus, attention will be directed chiefly to its pathology and treatment. Some advance has been made in late years in the knowledge of the nature of this formidable malady. There can be little doubt, whatever may be its modes of causation, that it includes irritative disease of the gray matter in certain regions of the spinal cord and medulla oblongata, more especially of the latter. From these central diseased parts excitations are propagated along the motor tract, down the medulla and cord, and thence along the motor nerves to the affected muscles.

Notwithstanding it has been held that the principal seat of disease is in the muscles, yet there is no evidence worthy of the name to support such a view. Again, there is no good reason for supposing that the motor nerves themselves are the real seats of the affection. They are simply the conductors of excitations to the muscles from the diseased centres in the cord and medulla. That these latter are the real seats of disease in tetanus, there can be no reasonable question. That it is chiefly in the gray matter, and partly in the white columns, may be regarded as settled by the most recent post-mortem investigations, as well as by the *tout ensemble* of the morbid phenomena during life. A study of the morbid appearances of the cord and medulla show in general the following results: There have been found plain evidences of acute myelitis affecting certain tracts in the central nerve axis. In the spinal cord, the chief seat of disorder appears to be the posterior cornua, and the contiguous central gray matter. At times the disease invades the related white columns. The cervical portion of the cord

[1] See Travers on Constitutional Irritation.

[1] Schweiz. Zeitschrift für Heilk., i., p. 356, 1863.

appears to be the seat of the more pronounced changes. These parts have been found intensely congested; the nerve-cells within the morbid areas, and their processes, have been atrophied, or the latter had even disappeared. The cell contents have been found clouded with pigment-granules. Their nucleoli were obscured or had disappeared. Fine granular matter has been found in the "ground-substance" of the gray matter, and small accumulations of myelocysts have been observed in the posterior and lateral white columns, and also small cavities in the gray substance have been found (Michaud). At times fat-granules have been observed in or about the diseased nerve-cells, and "hyaline masses" and dark granules are found in the adventitia of the vessels (Aufrecht). But the appearances observed in the cord depend much, of course, on the duration and other circumstances of the case. Other changes, less constant and subordinate in importance, have been found elsewhere. Those mentioned are the more constant. That the myelitis found to exist in some cases, is the characteristic and necessary morbid anatomical factor, cannot be affirmed. For in some reasonably careful post-mortem examinations no such appearances as have been above described have been found. Then it is to be remembered that tetanus is not a common result in cases of undoubted myelitis, while abolition of reflex excitability and paralysis are common symptoms of myelitis.

The myelitis, with destructive morbid changes, found in fatal cases of tetanus, is to be regarded rather as an incident than as the essence of the disease. The congestion of the cord and of the medulla which is found to exist, cannot be very intense, otherwise, as in the acute ascending paralysis of Gandry, and in common congestions of the cord, which transcend the limits of moderate hyperæmia, there would be lowered rather than exalted excitability of the cord and medulla,—the opposite of what we see in tetanus.

Whatever may be said as to the intimate nature of the morbid process, there is every probability that the effect is to greatly augment the reflex excitability of the spinal cord and medulla.

Clinically speaking, this is the capital feature of tetanus. In this respect, if in no other, tetanus resembles strychnia poisoning. The central mechanism of the medulla and cord respond with morbid facility and explosive violence to the sensitive or excitor impressions which reach them. But a comprehensive survey of the phenomena of tetanus will leave little doubt of the existence of an irritative lesion of nutrition, localized chiefly in certain not very well-defined tracts of the gray matter of the cord and medulla, and not involving to any great extent either the æsthesodic or sensory, or the pure motor tracts of the gray matter, but rather intermediate regions through which the transfers in reflex action are made from the sensitive to the motor apparatus of the central gray. Following in the wake of this (as it must be regarded) "systemic" disease of the gray matter of the spinal axis, is a moderate hyperæmia. In cases of recovery the morbid action probably does not go beyond the limits just described. But in fatal cases, it passes on to destructive myelitis, unless the progress of the case is suddenly terminated by an invasion of the respiratory or cardiac centres in the medulla.

Such seems to be a fair probable outline of the seat and nature of morbid action in the disease under discussion.

At this point a question arises, whether the enormous increase in reflex excitability, characterizing tetanus, is apparent or real. After a careful study of the disease it seems probable that the exaltation is both real and apparent. That it is in some measure real, that it is dependent on disease of the nerve mechanisms through which the reflexes occur, few would thoughtfully question. But many would hesitate, perhaps, before admitting that the exalted reflexes depend in part on an embarrassment or removal of cerebral inhibitory influence from the diseased zones in the cord and medulla. It may be assumed as highly probable, that distinct bands of motor fibres descend from the motor regions of the brain, to proceed without interruption to enter at various levels the central gray tube. One of these bands conveys the "orders of the will" down into the various horizons of gray matter in the cord and medulla which tend to excite these latter to action, while the other band may be assumed to conduct downwards into the gray matter of the spinal axis an inhibitory influence from contral centres in the brain. Now it seems not impossible that the exalted reflex excitability of the cord or medulla or both depends partly on a removal of inhibitory influence. This supposition not only necessitates the hypothesis of separate inhibitory mechanisms in the gray matter of the brain and cord, and connecting bands of fibres, but that in tetanus the spinal apparatus for inhibition shall be specially affected. Both seem probable. But whether we account for the augmented reflex excitability in these or in other ways, no doubt can exist as to the fact of its augmentation; granting then the existence of central disease of the kind described, the question arises as to its causation.

Various suppositions have been entertained on this point. The more important

hypotheses as to the causation of the central disease are the following:

1. It has been attributed to a poison circulating in the blood, either *sui generis* or rheumatic. The *materies morbi* in some unknown manner attacks the cord and medulla and perhaps other parts. In this manner the disease is caused. (Martin de Pedro. Heiberg.)

2. Again, it has been conceived to depend essentially on "individual predisposition." The same accidental or exciting causes acting on a healthy organism, it has been thought, will not produce the disease, as when the predisposition is present. (Pieratorie and others.)

3. It has been attributed to exposure to sudden cold, as during the cold nights in hot climates, or to other conditions and peculiarities of climate.

4. It has been finally attributed to nerve-wound, and to an ascending neuritis, which begins at the wound and invades the cord. Those who hold to this view differ among themselves as to what are the peculiarities of nerve-wound upon which the production of tetanus depends. In the opinion of some a nerve-wound is sufficient, followed by simple irritation or an ascending neuritis, while others hold that a ragged wound with partial division of a nerve, followed by a putrid condition of the wound, are necessary as causal factors.

Such are the principal modes of accounting for the central disease.

As regards their relative value, it may be said that the hypothesis of "individual predisposition" is neither capable of proof nor disproof. It may or may not be present. As regards the toxic theory, there is but little evidence in its favor, and it is, in many cases at least, wholly without probability. As to the hypothesis of local irritation from nerve-wound and central neuritis, as a final result, it may be declared as the most probable of all. But in many cases no such state can be shown certainly to have existed.

On the whole, it seems most probable that the central disease can be caused in a variety of ways, but that most commonly the cause is traumatic, and involves a nerve-wound. So much, then, in the way of an outline of the nature and pathology of tetanus. To enter fully into a discussion of this subject would exceed the limits of this article. As to symptomatology and diagnosis, nothing need be said in this place. They are fully discussed in the original article to which this is appended.

But when the central disease is once established, it is worth while to inquire in what manner the convulsions are produced. The diseased central mechanisms cannot act of their own accord. They must be excited from without. Here it is important to note that almost any excitation, however slight, whether by way of the peripheral sensory nerves, as from the skin, or from the mucous surfaces, especially from those of the laryngeal zone of the respiratory tract, or from the alimentary canal, or by way of any of the nerves of the special senses, or whether from the brain above, as a result of emotional excitement even moderate in degree, no matter from what source or how slight the excitation, an attack of spasms is likely to arise in the simple reflex way.

We now pass to the question of treatment. If we consider the pathology of the disease as just set forth, with a view of learning indications for treatment, we find at once a necessity for securing the action of such agents as will diminish reflex excitability of the nervous centres, and for cutting off rigidly every possible source of excitation which might rouse the centres and lead to an attack of convulsions. Upon looking over the therapeutical experiences on record, we shall find that any measures for relief which have proved useful have fulfilled these indications.

It would be easy to give a long list of remedies which have been proposed and tried, generally with little or no success.

It is understood, of course, that it is necessary to give every possible attention to a wound known or suspected as affecting a nerve-trunk, especially if it involves trunks of the sacral or brachial plexuses. These points, however, are so manifest and imperative as to hardly require mention in this place. Operative procedures, unless for the division of a lacerated nerve, or for some similar purpose, are generally inapplicable.

As regards the medical treatment of tetanus, the drug which has acquired the most reputation is chloral hydrate. To be useful, however, it must be given early and in large doses. As much as 1120 grains have been given in twenty-four hours, in a case cited by Dr. Kane, in a recent paper on "Chloral in Tetanus." The drug acts, at least, by diminishing reflex excitability in the nerve centres, and thus preventing, or tending to prevent, the spasms. It has been used in various ways, but should be given as a rule by the mouth or by the rectum.

Next to chloral, chloroform has been of the greatest service. But its action is similar to that of the chloral, and is not so enduring. It is probable it could seldom be substituted for the latter with advantage.

In view of what has been said as to the pathology of tetanus, and of what we know about the action of the bromides, it might be surmised *a priori* that they would be useful in the treatment of the disease. Such, in point of fact, is the teaching of experience. But as in the case of the

chloral, so with the bromides, to be useful the doses must be large and frequent. These remedies, indeed, may be combined with advantage. Everything will depend on promptness and boldness in the use of the articles chosen.

Often other remedies have acquired some reputation in the treatment of tetanus. But none now known are worthy to supplant the agents just mentioned. Calabar bean may be of some advantage in combination with other drugs, but in most cases would complicate treatment without increasing the chances of success. Curara has been used, but from what is known of its action, it is difficult to see how it could be useful. It acts, probably, chiefly on the terminations of the motor nerves (end-platten), and, therefore, not in the *locus morbi.*

It would hardly be useful to the reader to burden our pages with farther discussion on the therapeutic management of tetanus.

One of the most important considerations lies in prevention as far as possible of every form of excitation. Not a sound should be permitted possible to prevent. All strong and sudden illumination of the patient's chamber should be sedulously avoided. No physical shocks, or handlings, or voluntary movements, should be permitted, unless the most necessary. All emotional excitement must be avoided as far as possible.

It is highly probable that but few surgeons are as fully impressed as they should be with the importance of the recommendations just made. It is highly injurious to give active purgatives during the progress of the disease, unless in the presence of a most urgent necessity. After the bowels have been once moved, early in the history of the disease, they should be permitted to rest.

If the treatment is to be successful it must be promptly instituted, and followed with the utmost vigilance during the first few days, or the chances of success are small.

In this article very few authorities have been referred to. It has been the aim of the writer, as in the other notes on surgical nervous affections in these volumes, to give brief suggestive discussions on their pathology and treatment, rather than accounts of the conflicting opinions of various authors, or practically useless details in symptomatology.

DELIRIUM TREMENS.

By A. W. Barclay, M.D.

Revised by Roberts Bartholow, A.M., M.D., LL.D.

The name "Delirium Tremens," which, like so many others used in medicine, has been objected to on account of its want of scientific accuracy, is, perhaps, on this very account, the best that can be adopted to characterize a disease with the real pathology of which we are as yet so little acquainted. Like many other affections of the nervous system, it is marked by symptoms so well defined as to leave us in no doubt as to its reality, while they also serve to distinguish it from other forms of disease with which at first sight it might be supposed to be closely allied. Half a century has scarcely elapsed since it was first discriminated from the delirium caused by inflammation of the brain; and since that time, though much has been written on the subject, so little light has been thrown on its true causation, that the most opposite modes of treatment have been recommended for its cure.

The first distinct notice of the complaint is contained in a pamphlet published by Dr. Pearson of Newcastle in 1801, reprinted in the *Edinburgh Medical and Surgical*

Journal in 1813,[1] soon after the appearance in that periodical of papers on the same subject from the pen of Dr. Armstrong.[2] In the same year the attention of the profession was more generally attracted by the publication of Dr. Sutton's treatise,[3] who strongly advocates the same views as those enunciated by Dr. Pearson, [and to whom we are indebted for the term "delirium tremens." There are, however, well-founded distinctions between acute alcoholic delirium; delirium tremens, an acute exacerbation occurring during the course of chronic alcoholism; and a delirium tremens accompanying some intercurrent malady in the subject of chronic alcoholism.[4]]

The practice then commenced has been more or less followed by the majority ever since, and the successful issue of cases treated on a wholly different plan, serves only as an illustration of the principle which ought never to be lost sight of in weighing the merits of opposing views, viz., that in a large number of instances disease has a tendency to run a natural course and to terminate in recovery; and that consequently the so-called "cure" takes place, not because of the treatment adopted, but either quite independently of it, or even in spite of its being unsuited to the particular case to which it has been applied. Another source of error in drawing conclusions from the result of particular cases, which is too often overlooked in the eager desire to establish a favorite or original mode of treatment, is to be found in the different degrees of intensity and severity exhibited by a succession of cases; among some a fatal issue is no uncommon occurrence, while others have scarcely presented an unfavorable symptom. This may be verified by the very great difference in the mortality at any of our public hospitals at different periods, although the treatment may remain practically the same.

Pathology.—The real nature of the affection has by no means been made out by morbid anatomy. The post-mortem appearances only reveal to us the mode in which the fatal termination arrived; they throw no light on the origin of the disease, or the morbid conditions on which it is dependent. We know not in what way the nerve-structure is altered by continued habits of dissipation; or how the blood, contaminated by the frequent introduction of alcohol into its current, serves to excite in the deteriorated brain that peculiar delirium, tremor, and insomnia, which so distinctly mark the disease at the bedside of the patient. The condition is one to which we are almost disposed to apply the term of "disordered function," because the evidence of the disturbed action of the organ is so much more distinct than that of the change of structure which no doubt goes along with it. This is more or less the case at present with all diseases of the nervous system, in the minute investigation of which so little progress has been made.

Still, the information derived from anatomical research is worthy of study, because, as it tells how death is actually brought about, it offers suggestions as to how the fatal event may be prevented or warded off. The striking appearance is that of excessive serosity, whether contained in the ventricles, or under the arachnoid, or pervading the whole tissue of the brain, so as to give rise to the term so commonly in use of "wet brain." Occasionally turgidity of vessels is observed; but this is much more rare as a pathological fact in cases of simple delirium tremens, and may, not without reason, be alleged to have been produced by injudicious treatment. Congestion of the brain is the invariable result of opium-poisoning, and here too we occasionally meet with serous effusion. This circumstance it is which gives importance to the objections raised against its administration in delirium tremens; but it may be remarked that the turgidity of vessels and the effusion of serum stand to each other in an inverse ratio in the two cases; in the one congestion often occurs without effusion, in the other effusion without congestion, even when opium has been given freely.

Another cause of congestion sometimes comes into operation, viz., the employment of means of restraint. The struggles of the patient to be free from an impediment which he cannot understand, hurry the heart's action and interrupt his respiration, and thus very materially promote venous congestion. It is therefore the duty of the practitioner to watch very closely the effects of such measures where he is under the necessity of having recourse to them. The livid hue which sometimes pervades the face and neck and ears of the body after death, due in some degree no doubt to altered blood, betokens a condition closely akin to strangulation, and is only seen in those cases in which great violence on the part of the patient has been met by undue restraint.

[Alcohol is a very influential factor in the production of many forms of disease. Without developing the complexus of

[1] "Observations on Brain-fever," by Samuel Burton Pearson, M.D.; "Ed. Med. and Surg. Journal," vol. ix, p. 326.

[2] Ibid., pp. 58, 146.

[3] Tracts on "Delirium Tremens," on "Peritonitis," and on the "Gout," by Thomas Sutton, M.D.

[4] ["On Alcoholism," by Dr. V. Magnan. Translated from the French by Dr. W. S. Greenfield, London, 1876. H. K. Lewis & Co.]

symptoms known as chronic alcoholismus, it may slowly induce the peculiar lesions of sclerosis of the liver, Bright's disease of the kidneys, dementia paralytica, etc. We are here properly concerned with those alterations of structure, out of which delirium tremens may proceed, for this malady may be defined as an acute exacerbation arising in the course of chronic alcoholismus. These changes may be comprehended in the two words, sclerosis and steatosis—the former consisting in an overgrowth of the connective tissue structures; the latter in fatty degeneration of the anatomical elements. Without entering too minutely into the subject, it will suffice to say that the lesions of the digestive tube consist in hypertrophic thickening of the mucous membrane, atrophy of the gland elements, abnormal pigmentation, the catarrhal process, etc. The liver presents typical examples of connective tissue overgrowth in cirrhosis; of steatosis, in fatty degeneration. Not unfrequently the two processes are conjoined—sclerosis in Glisson's capsule, and steatosis in the hepatic cells. The kidneys likewise present examples of both forms of degeneration, the connective tissue undergoing hypertrophy, the cells of the tubules becoming fatty. The muscular tissue of the heart, like the muscular tissue in general, becomes granular, the arteries atheromatous, and the veins hypertrophic. For our present purpose, more important are the structural alterations occurring in the brain. The cells of the gray matter, the neuroglia, the perivascular lymph-spaces, and the walls of the vessels, are affected in varying degrees with the processes of sclerosis and steatosis. In the examination of fatal cases of delirium tremens, minute hæmorrhagic extravasations are not unfrequently found, and these may be the prelude to the pachymeningitis hæmorrhagica, which is so important an element in the morbid complexus of chronic alcoholism. Such is the groundwork on which is constructed febrile delirium tremens. The changes may be in their infancy, but some alteration of the structures enumerated is necessary to the development of this affection, and without them it becomes impossible. The morbid anatomy of delirium tremens is not *per se* of a pronounced character.]

Clinical study alone furnishes us with data on which we can rely in forming any notion of the true nature of the disease; and there seems no reason why, with caution, correct inferences may not be drawn from this source when anatomy fails as a guide. First, it is to be remembered that the disorder is not brought about by a first debauch; that a necessary element in its causation is the *habit* of dissipation. This habit is not to be measured by the actual quantity of stimulants taken: a patient in whom the nervous centres are easily acted on becomes excited and tremulous, "nervous" as it is often called, by very small quantities taken daily at unsuitable times; while in some remarkable cases two or three bottles of ardent spirits have been consumed every day for months, or even years, before the disease has been developed. Occasionally cases are seen in which the habit having been for a time restrained by circumstances, delirium supervenes immediately on excessive intoxication; and while these present many analogies to true delirium tremens, they differ from it not only in the more marked features of the attack, but also in this important fact. that the delirium is excited by the intoxication. Most writers have pointed out the necessity of such a distinction with reference to treatment, and this form of delirium has been not inaptly called the *delirium ebriosorum*. This class of cases is that to which alone the view is applicable that alcohol acts as a direct poison, like belladonna or stramonium; and that the delirium is in the one case, just as in the other, due to the presence of a material poison introduced into the circulation from without. But even in such instances the antecedent is still essential; the habit, though restrained by circumstances, must have existed; in the first instance the abuse of alcoholic stimulants may produce a condition of nearly complete stupor, but it never gives rise to delirium. Delirium is unmistakable evidence of a prior change in the nerves or the blood, or more probably in both together.

Secondly, we have to take into account the exciting cause of the attack. Sometimes it commences in a person habitually intemperate, after a recent debauch during which little solid food has been taken, the appetite being lost, and the stomach in a state scarcely capable of performing the function of digestion; and we are led to the conclusion that the want of healthy nourishment is the main cause of the disorder. But it is very usual to find in such cases that there has been also some great mental anxiety, which has very probably led to the excess in the vain hope of "drowning care;" and this mental condition is not without its influence in producing the result, even without any very unusual amount of dissipation; the sleeplessness produced by mental anxiety, and the exaggeration of that nervous depression under which drunkards in their sober moments so constantly labor, are of themselves sufficient to hurry on an attack of delirium when the patient is already prepared for it. Next in frequency are those cases in which delirium tremens follows on an accident or injury attended with nervous shock, or supervenes during the continuance of low forms of

erysipelatous fever, and that unhealthy character which the reparative process in wounds so constantly assumes in persons of intemperate habits. In other instances, again, the disease arises under circumstances in which the usual amount of stimulus has not been obtained; and it has been too hastily concluded that its sudden withdrawal had brought on the attack; an opinion which seemed to be supported by the apparent benefit obtained from free stimulation during its continuance. The records of our various prisons, in which so many committals occur among habitual drunkards, would seem to negative such an idea; and we are constrained to look rather to the circumstances to which the forced abstinence is due, such as privation or illness, with their accompanying mental depression and want of food, as more probable causes, than to any diminution in the quantity of stimulants taken by the individual.

Thirdly, the clinical investigation of the disease has clearly led to the conclusion that it is one of depressed, and not exalted, vitality. The softness of the pulse, the muscular tremor, and the copious perspirations, are all so many proofs that there is no inflammatory action going on. In former days, when the presence of delirium led to its being classed among inflammations of the brain, and antiphlogistic treatment was consequently adopted, the mortality was frightful; and many of the older writers have spoken both of sweating and tremor as being of the worst omen in phrenitis, wholly unaware that these were symptoms of a different disease. For them they were only indications that antiphlogistic remedies would be ill-borne, and that, if already adopted, they must be abandoned. With the knowledge obtained by post-mortem examinations in more modern times, any idea of an inflammatory origin has been wholly abandoned; the wet brain of the drunkard is no longer regarded as a "very dangerous modification of meningitis," which exhibits none "of the actual results of inflammation."[1]

We are warranted by these observations in assuming—1. That the disease is one of exhaustion, in which, whatever be the change which has actually passed on the nervous system, the first indication for the practitioner is to guard against the approach of death by sinking, or by coma in consequence of passive effusion into the brain. 2. That it is not a direct form of poisoning, in which after a few hours of waiting and watching the poison will be eliminated by some secreting organ or other, and the patient will be restored to health, as happens in opium-poisoning or in intoxication (alcohol-poisoning); but that some obscure structural change has been wrought, and whether alcohol be present in the blood or not, there must have been some additional cause which has produced the delirium, and this generally of a depressing kind. 3. That, so far as the nervous system is concerned, the condition is such as we might expect to be generated by depressing causes, and treatment ought therefore to correspond rather to those forms of insanity accompanied by depression than to those which are characterized by excitement.

Diagnosis.—With reference to diagnosis, it is to be remembered that the history of the case is very often defective in the most material point—the indulgence of evil habit. Neither the patient nor his friends are quite willing to confess to that of which their better feelings make them ashamed; but while the knowledge of habitual excess gives certainty to the diagnosis, the disease may no less be developed in persons who may be thought by their friends to be very moderate in the use of fermented liquors, and yet who have taken more than their nervous system could tolerate. Very often the trade or occupation of the patient supplies this link in the chain of evidence by showing that he has been placed in circumstances of temptation; and if loss of appetite be at the same time complained of, the inference will generally be correct that the temptation has not been successfully resisted. It has been alleged that delirium tremens may be brought on by the habitual use of opium; and Sir Thomas Watson, in his admirable lectures, speaks of a medical gentleman of temperate habits who was on the verge of delirium tremens from mental excitement and anxiety. It has also been asserted that the opium-eater is liable to attacks of delirium tremens. Of the action of opium on the nervous system, in its habitual abuse, we fortunately know little in this country, and whether the one habit can produce the very same condition of the nervous system as the other, it would be idle to speculate; certainly the change in the character of the blood which we know to result from the abuse of alcohol cannot be excited by opium. It does seem unwise to employ this name to designate any form of delirium accompanied by muscular tremor, occurring in persons of known temperance. Such a condition may be seen in cases of severe typhus; indeed, in rare examples, so close is the resemblance that a superficial observer may be readily deceived before the patient is put to bed and the mulberry rash discovered. Not unfrequently the delirium of erysipelas or of rheumatic fever presents features closely resembling delirium tremens; but it is only in the intemperate that the genuine disease is developed. This view may be regarded as an over-refine-

[1] Abercrombie, "Diseases of the Brain," Part I., sect. iv., § 8.

ment, but in our ignorance of its real mode of causation, we cannot class under the very same category cases which are dissimilar in this important antecedent; and it is safer to speak of them as analogous than as identical, especially when a closer scrutiny very generally discovers also some dissimilarity in the symptoms present. We would therefore restrict the term absolutely to those cases in which habits of excess have existed.

Next in order of events comes the exciting cause, which may act either primarily on the mind or on the nervous system, as the organized structure through which mind reveals itself; just as in the analogy of other forms of diseases we see acute mania brought on by mental excitement, and delirium in phrenitis or in fever produced by actual change in the brain or in the blood with which it is supplied. The character of the exciting cause has but little importance in the diagnosis of the disease; it is always one of a depressing kind, and consequently has an important bearing on treatment. [The term *febrile delirium tremens* is applied by Magnan to the malady which arises in the course of chronic alcoholism, usually in consequence of increased excess, or of habitual excess with new anxieties of mind or other causes of moral depression, or, of failure in digestion and assimilation. Again delirium tremens is developed in the subject of chronic alcoholism, in consequence of the access of some serious malady, notably of pneumonia, or as a result of traumatism. Alcoholic pneumonia is very insidious. Objectively the disease appears to be delirium tremens, and is so diagnosticated, and the pneumonia, if discovered, is said to be a complication, but it is really the substantive disease, and the delirium tremens is an accident of the disease proper occurring in the subject of chronic alcoholism. So frequently is an error of diagnosis committed on this point, that in every case of delirium tremens should the lungs be carefully explored. In the absence of characteristic symptoms of pulmonary inflammation, the patient's delusions may suggest a course of investigation, as they are, under these circumstances, connected with the breathing organs sometimes. Thus the patient declares that the air is stuffed, that his nose is obstructed, that demons are sitting on his chest, etc.]

The actual attack is usually ushered in by sleepless nights and restless days, and there is almost always more or less of febrile disturbance. Exceptions to this rule more especially occur in surgical practice; and sometimes when everything seems to be going on favorably, delirium suddenly commences almost without warning. In all cases of severe injury in persons of intemperate habits, the surgeon must be prepared for such an event, and must guard against its invasion by husbanding the powers of his patient, and sustaining his strength from the first by suitable nourishment and the judicious employment of stimulants when necessary.

The features of the disorder are so striking, that very little experience is sufficient to render its discrimination by no means difficult. The chief points to be observed, in addition to those derived from the history of the case, are the following:

1. *The character of the delirium itself.*—This is especially marked by the presence of one dominant idea, which has generally something of unpleasantness mixed up with it, and excites the individual to constant activity. It is, as denominated by Sir T. Watson, especially a "*busy* delirium." The patient is either harassed by some worry connected with business, or he is alarmed by the presence of some loathsome or horrible object, and he is in constant agitation to have a business-matter arranged, or to rid himself of the object of his alarm. He is perpetually jabbering on this one subject, and getting out of bed, or pulling his bed-clothes about, under the influence of the same predominant idea, which from time to time changes from one thing to another. But there is no violence or maniacal excitement; he has no tendency to injure himself or others, and his only risk is that of getting out of the window by mistake, or rushing out of doors in his night-shirt in the pursuance of the idea which rules him for the time being. Still he is generally managed with comparative ease by any one who combines firmness with gentleness, and only frets and rebels against unnecessary restraint or harshness. During the earlier periods of the attack he will generally put out his tongue, answer questions put to him, and do as he is directed, and there is none of the incoherent rambling and muttering of words without meaning and connection seen in other forms of delirium; it is only when the brain begins to be oppressed by serious exudation that such symptoms are seen.

2. *The existence of tremor along with the delirium.*—This feature is so marked that it has given its name to the disease. It is not quite like that seen in the weakness and utter prostration of fever when there is delirium and subsultus; it is more allied to the nervous trembling of a very excitable person under the influence of some mental impression, which for want of a better name we call "nervousness," strangely modified, however, by the peculiar restlessness of the delirium which it accompanies. The patient is constantly on the move, and every movement is made in the same tremulous, unsteady manner. Even before the delirium has actually commenced, or during convalescence, there is a peculiar hurry

and agitation about his actions; he puts out his tongue, or thrusts forward his arm for his pulse to be felt with a jerk, or he rises up in bed with a bound: there is a want of steadiness and deliberation in everything that he does. This combination of hurry and unsteadiness is one of the most decided evidences of the approach of the disorder, before anything like delirium is seen.

3. *Restlessness and want of sleep.*—These, though not peculiar to this form of delirium, are its invariable concomitants. The predominant idea keeps the patient in a constant state of imaginary employment; he is no sooner persuaded to lie down than he is up again, or, if he remain in bed, he is perpetually pulling about or arranging his bed-clothes with the same object. Sleep under such circumstances is wholly impossible; but no doubt there is more than this, for sleeplessness generally precedes the delirium; and it is only in exceptional cases that this indication is wanting. In other forms of delirium, insomnia generally follows the existence of delusion, whereas in delirium tremens it very often precedes it for several days.

4. *A condition of general depression of the vital powers.*—This is perhaps the most important point in the consideration of the disease, because, while it gives certainty to the diagnosis, it also indicates the true line of treatment. Its importance, as one of the sources of our knowledge of the pathology of delirium tremens, has been already pointed out, and this knowledge becomes in its turn the only basis of sound and rational treatment. It is not enough to determine that an habitual drunkard is suffering from delirium with some amount of tremor, and go on to adopt a certain routine practice; for his condition may be the direct effect of a recent debauch, while the blood is still poisoned by a large quantity of alcohol, which is producing irritation of the brain and congestion of the liver; it may, in short, be the *delirium ebriosorum*, and not true *delirium tremens*, and the treatment suited for the one may be useless or injurious to the other. We must go a step further, and inquire into the condition of the pulse, skin, and tongue; whether they indicate febrile action of an inflammatory or, at least, congestive kind, or whether they prove that the condition is one to which these names are wholly inapplicable. The pulse probably will be, as in most conditions of debility, more frequent than in health, but the skin is not dry or burning; it is usually covered with moisture, and the perspiration occasionally becomes very profuse. The tongue at the same time is seldom dry or brown; sometimes it is tolerably clean, more commonly coated with a moist whitish or creamy fur, and having a flabby or œdematous aspect. Dryness of the tongue or redness at its tip and edges, with a roughish fur on its dorsum, may be regarded as pointing rather to the delirium of over-stimulation than to the genuine type of the disease. The absence of heat of head, the freedom from local pain and uneasiness, and the dilatation of the pupil, also serve as so many distinct indications that the disorder is nowise related to phrenitis, with which there is now hardly any excuse for its being confounded. The conjunctivæ are very often suffused, just as they are in typhus, a disease, like it, of a depressing kind, the analogy to which has been already referred to, and did not escape the observation of Dr. Pearson.[1]

Treatment.—The opposite views of the treatment of delirium tremens taken by various writers are at first sight very unaccountable. The explanation, however, is to be found in the absence of any pathological data as to the exact nature of the disease, and in the empirical nature of our practice. It may indeed be to a certain extent called a rational empiricism, inasmuch as we know both the usual causes of a fatal result, and the invariable mode of recovery by sleep. To avoid the one, and to aid in the production of the other, is the rational aim of the medical practitioner, and the discrepancy of opinion has in great measure arisen from too exclusive regard being paid to one or other of these parts of treatment.

Some years ago a patient under the care of Mr. Jones, of Jersey,[2] having by mistake swallowed one ounce of tincture of digitalis when almost *in articulo mortis*, made such a rapid recovery without any unfavorable symptoms that Mr. Jones was induced to employ it extensively in the treatment of the disease. His conclusion was that it very generally succeeded in producing sleep when administered in large doses. [The use of digitalis has been revived again, notably by Dr. Fothergill. The indications for its employment are a weak heart and low tension of the arterial system. The merely weak heart should not be confounded with the *fatty heart*, in which digitalis is hardly proper. It is in a high degree probable that the cases of delirium tremens, in which the best results are obtained from digitalis, are examples of alcoholic pneumonia.] In other hands the result has not been quite so satisfactory, and most practitioners shrink from the responsibility of giving the remedy in such poisonous doses as we are assured can alone prove successful. Various other remedies have been tried with the somewhat mis-

[1] Op. cit.

[2] Med. Times and Gazette, September, 1860.

taken view that sleep will not be procured except by powerful agents employed in heroic doses. Such a doctrine cannot be too strongly reprobated.

The evidence of the older writers is clear and distinct on one point, viz., that when delirium tremens was mistaken for phrenitis, and treated by depletion and antiphlogistic remedies, the mortality was very much greater than when the distinction had been made and the treatment by opium introduced. It is not possible to trace the causes which led to this change in treatment. Dr. Sutton attributes the discovery to accident; he offers no theory to account for its success, but claims for it the same confidence among the profession generally with which its success had inspired himself. The reaction which, to a certain extent, has taken place, may be ascribed to the indiscriminate manner in which the drug has been subsequently administered, as compared with the caution used by its earlier advocates. The cases furnished by the opponents of the treatment by opium prove clearly that in many instances simple attention to the functions of digestion and elimination, with good management, is sufficient to insure recovery, and that opium may sometimes at least be dispensed with.[1]

In the *earlier stages* of the affection, when the case is only marked by anorexia, disorder of stomach and troubled sleep, its further progress may very generally be arrested by remedies calculated to restore the functions of the stomach and liver, and to evacuate the morbid matters which we know must have accumulated in the blood by long habits of dissipation. At the same time the strength of the patient must be sustained by proper nutriment, and powerful cathartics must be avoided. A patient threatened with delirium tremens cannot bear any decidedly lowering treatment; for, as has been already shown, the exciting cause of the attack is most frequently of a depressing kind, and abstinence from food generally plays a very prominent part in its development.

These indications are perhaps best fulfilled by the administration of small doses of blue pill, followed by a warm and mild aperient; nitric acid in combination with bitter infusion, with the adjunct of some stimulant diuretic, is often highly beneficial; sometimes even more powerful tonics may be usefully administered, such as quinine and sulphuric acid. When the red edge of the tongue and tendency to vomit indicate a more irritable state of the stomach, such as is likely to be produced by the direct action of the stimulant on its mucous membrane, effervescing draughts with an excess of ammonia are to be preferred to remedies more decidedly tonic; while the irritability is soothed by the application of a sinapism to the epigastrium [or a simple saline laxative. A seidlitz powder will, at the same time, allay the irritability of the stomach, and remove the unhealthy contents of the intestines. This may be followed by tincture of nux vomica, which acts as a tonic to the stomach, heart, and brain. If vomiting is persistent, and much glairy mucus and bilious matter, which may or may not be streaked with blood, comes up, a mixture of bismuth and carbolic acid suspended in glycerin, is highly effective. If, on the other hand the vomiting is chiefly cerebral, there is much gagging without result, and the vertigo is pronounced, bromide of potassium is most serviceable. The best aliment when the stomach is so irritable is milk and lime-water, one-fourth to one-half of the latter.] The great object of treatment is to enable the patient to take and to assimilate a sufficient quantity of proper nourishment; without this the disorder will get worse. And here perhaps lies the greatest difficulty. Solid food is absolutely refused; even soup or beef-tea may cause such a loathing that the patient cannot be persuaded to take them, or they may be rejected by the stomach. In such circumstances, the feeling of prostration causes him to have recourse to some stimulant as the "only thing which will stay down," and this again increases the anorexia. Sometimes, indeed, the medical attendant feels the same necessity; and then good ale or porter, or even wine, are to be preferred to spirits, as containing some amount of nutriment; and it should be made a *sine quâ non*, in granting the indulgence, that solid food even in the smallest quantity is taken with the beer, which should be given only at stated intervals, and not taken as fancy directs. [If the case be one of acute alcoholic delirium due to the immediate poisonous effect of the alcohol, there can be no question as to the propriety of its complete withdrawal. If, however, the case is one of chronic alcoholism, and the delirium is due to recent excess, the spirit being readily retained, there can be no injury from suddenly stopping it, although it may be questionable whether the withdrawal is the best course to pursue. In old drunkards, however, it sometimes happens that no form of aliment can be retained and digested without the presence of some alcohol, and the reason is that the organs of digestion—of the primary assimi-

[1] See especially, Clinical Illustrations of the Pathology and Treatment of Delirium Tremens, by Prof. Laycock, Ed. Med. Journal, vol. iv., p. 289, 1858–9. But it may be remarked that the instances there recorded present such a degree of severity as very often marks the disease in this metropolis. Perhaps something is due to the different stimulant in common use in Edinburgh.

lation—are so habituated to the goading of the stimulant as to be unable to work without it. Of a large number, it is incontestably true, that a moderate amount of spirit enables the stomach to take and digest food, and if the alimentation is carefully conducted, and the other conditions are favorable, sleep comes in the natural order, without the intervention of medicine. It is wise, as above stated, to administer the stimulant with or after food.] Along with these measures, the nervous agitation is decidedly calmed and the exhaustion of want of sleep may be avoided, by giving a morphia draught at bedtime, [and very often the less questionable remedy, bromide of potassium will suffice.]

When *delirium* has fairly set in, we ought to ascertain, if possible, how long it has lasted, because it is almost vain to hope for the immediate occurrence of sleep, however large the dose of opium may be. The same quantity of opium which has failed the first day may be completely successful the second. If no treatment has been previously adopted, it is wise to commence with a dose of calomel, which should be accompanied by a grain and a half or two grains of opium, followed after some hours by a purgative. Congestion of the liver is so common with drunkards that the function of this organ demands our first attention; but caution must be exercised that the patient is not too much depressed by the remedies. An effervescing saline with excess of ammonia, and a few drops of laudanum, may be given every second or third hour, with a view to calm nervous excitement and moderate the restlessness of the patient. Whatever food can be taken is to be allowed; and according to the state of the pulse, more or less of some stimulant may be given from time to time. In these matters the attendant must be very much guided by the whim of the patient, the object being to sustain his strength; this must be done in the best way that the circumstances of the case will admit of, but over-stimulation must be carefully avoided. The idea that stimulants can cure the disease has no warrant in experience; and theoretically we may assume that if they do not prevent its occurrence in a man whose habits are those of constant indulgence, and who has been but lately under no restraint, they cannot cure the complaint when the same person is brought into the wards of the hospital. Still I think one cannot fail to be struck with the remarkable manner in which a tongue covered at first with a thick creamy fur becomes perfectly clean while stimulants are being given in such quantity as the exigencies of the case seem to require. No more complete justification can be offered for their administration, and when this effect does not follow, the practitioner is bound to reconsider his judgment and reflect whether they are really called for, and to what extent the needs of the system demand their continuance.

An opiate [or hypnotic] of some sort should be administered at bedtime and repeated once or twice, even when we do not expect to induce sleep, for the purpose of calming the delirium, which is always aggravated at night. The dose should be full, but in the first instance not unreasonably large until the idosyncrasy of the patient is known. It may be repeated at intervals during the night, and should be entirely suspended during the day.

If it be the great aim of the practitioner to procure sleep, he must not be tempted to give more opium than his patient will bear, and so complicate the case by superadding narcotic poisoning to the state of delirium tremens. It is always wise to interpose an interval of complete rest in the course of each twenty-four hours, and defer the administration of the opiate until night, when other circumstances tend to favor its operation. Caution is especially called for if there be contraction of the pupils, which, as it is not a usual condition in delirium tremens, points either to an excess of narcotic action or to already commencing effusion on the brain; and in neither case can large doses of opium be beneficial. Not unfrequently death occurs under circumstances very similar to the effects of narcotic poisoning, and it is not always easy to satisfy the friends that the medicine had nothing to do with the development of the symptoms. In a scientific point of view, it can never be regarded as judicious treatment to push the action of a remedy which, in its operation on the brain, gives rise to a somewhat analogous train of phenomena. The real function of the medical attendant is to obviate the tendency to death, in whatever mode it is most likely to occur, and by those who oppose the use of opium it is alleged that want of sleep is not to be reckoned among the causes of a fatal issue. It is no doubt true that in health a man cannot die from want of sleep as he may from want of food; but delirium tremens is not, surely, the only disease in which prolonged wakefulness may terminate in exhaustion of brain and coma, and in which the artificial induction of sleep may restore its normal functions, and arrest the morbid action which might lead to such a result. [Since the discovery of chloral, it has largely taken the place of opium or morphia to procure sleep in delirium tremens. It has these distinct advantages: it is not apt to disorder the stomach, to arrest the secretions, to constipate, or produce after nausea and depression. Chloral should be

given in moderate doses, and its administration should be entirely secondary to the calmative influences of food and quiet. It is rarely necessary to give more than fifteen grains, and this quantity may be repeated at the interval of two hours. Chloral has unquestionably caused deaths by paralyzing the drunkard's weak heart. The danger of its administration in cases of fatty heart is increased by combination with bromide of potassium. The latter may be sufficient of itself to quiet the "horrors," in a mild case. If there is reason to suspect the existence of a fatty heart, morphia is preferable to chloral, and the hypodermic method to the stomach administration. The combination of morphia and atropia is more effective as a hypnotic than morphia alone. Large doses are unnecessary, for it is not desirable to bring on morphia narcosis, or to excite coma vigil, from which the patient passes into insensibility. From one-sixth to one-fourth of a grain of morphia, and one hundred and twentieth grain of atropia, are suitable proportions for this method. Habit, idiosyncrasy, and the state of the circulation, must enter into the question of dose and mode of administration, and the repetition of the dose depends on the effect of the first, the condition of the stomach, tongue and brain. If the delirium lessens, the temperature declines, the tongue remains moist, the trembling diminishes, the remedy is doing good and can be repeated in a few hours, if need be, to procure sleep. If, on the other hand, the delirium increases, the body-heat is higher, the tongue dry, and food is not taken, the injections are doing harm and ought to be discontinued.]

But unquestionably the moral management of the patient is the point of most importance in practice. Coercive measures are always prejudicial, and are only justifiable under the most unavoidable necessity. The patient may almost always be controlled by firmness combined with a soothing and gentle manner, if his fancies be humored and not contradicted. Much stress is justly laid by the older writers on this part of the treatment, and it has been unfortunately too much lost sight of in modern practice. Opium and the strait-waistcoat have been sanctioned, from the difficulty of treating such cases in hospital with a limited staff of nurses. It is to be feared that sometimes a fatal termination might, not without reason, be charged against such treatment, and the opium has borne the blame when the forcible restraint was really more in fault. Dr. Pearson's notes on this subject are quaint and instructive, although few would be disposed to follow out to the letter the various injunctions laid down. Perhaps the arguments against the treatment by opium would have found fewer supporters but for the neglect of such an important element of success.

Whatever doubt may have been entertained in regard to the rules of practice now laid down as applied to the more ordinary forms of delirium tremens, all are agreed that when it supervenes on an accident or injury, or in the course of an attack of erysipelas, the safety of the patient depends upon free stimulation and the exhibition of opium. In very many cases it is vain to talk of what may be the most scientific mode of treatment, because the patient cannot be persuaded to submit to it; but he may be induced to take some form of stimulant, such for example as a draught of porter, in which we may disguise a dose of laudanum to calm his wild excitement; and if it do no more, it at least helps to ward off fatal syncope, and gives nature time to do her own work in her own way.

Recently, attention has been called to the possibility of introducing narcotic substances into the cellular tissue, by what is called the "hypodermic method," in cases in which they have seemed to fail in producing their effect when taken into the stomach. In delirium tremens it is well to bear in mind that the assimilating powers of the stomach are always much interfered with, and that consequently, while the remedy itself is very likely to escape absorption, its presence in the stomach is apt to increase the anorexia and inability to assimilate proper nutriment, which stands so much in the way of successful treatment. Sometimes, too, the resistance of the patient prevents the administration of an opiate in the ordinary way; and in either case the injection of a few drops of solution of morphia under the skin may be practiced with perfect safety, if due caution be exercised. In this mode of treatment more than any other is there a danger of pushing the narcotism too far. The immediate risk attending the repetition of an opiate before we can be certain that it has been absorbed is obviated; and if sufficient time be allowed to pass before a second or any subsequent injection is practiced, and sleep is still not induced, there is a great tendency to go on with the treatment, forgetting that in such cases the brain may be ultimately poisoned by opium, and yet sleep be as far off as ever. Sleep, not narcotism, is nature's method of cure in delirium tremens.

When there is extreme prostration and the skin is bathed in perspiration, it is not unreasonable to expect benefit from the exhibition of tonics and astringents; personal experience, perhaps rather limited, has seemed to confirm this view. Quinine and acid in full doses, during the intervals of the opium treatment, have certainly been

well borne and apparently have done good in such cases.

To sum up: the natural mode of recovery is by sleep, which occurs in the milder cases spontaneously; the object of treatment in the severer cases is to bring about this result by the judicious administration of opiates. Full doses are to be repeated at short intervals for a limited time, and to be again resorted to after the lapse of some hours, if at first unsuccessful. The functions of the stomach and liver at the same time claim special attention, because they are almost always disordered in drunkards, and the consequent non-assimilation of food is one of the essential elements in the causation of the disease; the strength must therefore be supported by such nourishment as the stomach can bear, and, when necessary, by the administration of stimulants, while all needless coercion is to be carefully avoided. The great error in the treatment of the present day seems to be the regarding opium and stimulants almost in the light of specifics, while neglecting other important measures; it consists in the endeavor to "cure" by heroic means, in place of resting satisfied with aiding in bringing about the "recovery" of the patient.

HYSTERIA.

By W. S. Savory, Esq., F.R.S.

Revised by J. S. Jewell, M.D.

Hysteria would be much less interesting and important if its phenomena were confined to its occasional paroxysms, and its other characteristic and distinctive symptoms. An hysterical fit seldom presents any difficulty of diagnosis, for its nature is usually sufficiently apparent; and the same statement will prove true, although, perhaps, a little further inquiry will be sometimes needed, for many other of its less striking but not less decisive manifestations, such as the globus hystericus, and other milder forms of the attack.

But hysteria does not always assume this regular and characteristic form; on the contrary, it frequently occurs strangely disguised, and its essential features concealed in the garb of some other disease whose characters it assumes and whose symptoms it mimics. This it is which especially gives interest and importance to hysteria; which so often renders it a stumbling-block in the way of correct diagnosis, sometimes masking by its prominent symptoms the existence of a graver malady, but far more frequently by the similarity of its symptoms leading to the opposite error of mistaking a simulated for a real disease. And this form of hysteria has been aptly termed protean; for there are few diseases, the symptoms of which are not at times more or less mimicked by this singular affection.

The hysterical fit in its common forms is not likely to be mistaken. However much it may vary in duration and severity, its general characters are sufficiently obvious and well known, whether it consist merely in a violent and uncontrolled display of emotion, or appear fully developed. The deep and hurried inspirations at the commencement, followed by occasional sighs or sobs or screams; the sense of choking, leading to agitated movements of the hands about the neck, as if to remove some oppression there; the irregular muscular movements generally, such as struggling like a person contending, beating the breast, or tearing the hair; the withdrawal, more or less complete, of the power to balance and sustain the body; and with all this, seldom loss of consciousness, although sometimes sensorial disturbance; the flushed, but calm and not distorted, countenance; the closed and perhaps trembling lid, with the eye bright and natural beneath; the hot skin, excited circulation,

vehement action of the heart, which, however, subsides as the fit declines, the whole terminating either in violent laughter, with a copious secretion of pale urine, or in tears, or in a combination of the two, or in sleep more or less profound,—these symptoms are not to be misinterpreted. By the consciousness not being wholly lost, especially at the commencement; by the absence of well-marked and decided convulsions, limited to one side or to some portion of the body, the muscular movements being rather struggling and capricious; by the absence of all lividity, particularly of the face, and distortion of the countenance; in a word, by the absence of all signs of impeded respiration, which on the contrary is deep and sighing; and finally, by the subjects of the attack being almost always women at that period of their lives when the uterine functions are active, the hysterical fit is distinguished from every other. The duration of the fit may vary from a few minutes to several hours. Occasionally such paroxysms succeed each other at frequent intervals, the person remaining in the meanwhile in a drowsy state. In this way the attack may be extended over some days. In its slight and transient forms many of these symptoms do not appear. A very common variety is limited to what is termed the globus hystericus. A sense of uneasiness or discomfort is felt in some portion of the abdomen, usually in one of the iliac regions—and it is said to occur more frequently in the left—as of a ball or some solid body. This is described as rolling about, and then rising upward until it reaches the throat, when a sudden and alarming sensation of choking is experienced, but often attended with frequent attempts to swallow. This usually ends in a similar manner to the more fully developed attack.

Although the characters previously enumerated, when fairly developed, are peculiar, and sufficiently distinguish the hysterical from all other fits—for instance, from epilepsy, both by positive and negative symptoms—yet it occasionally happens that cases occur presenting features which may almost be said to be intermediate between these for the most part widely separated affections. Many of the symptoms of hysteria may be united with others which are ominous of epilepsy. This is what might be naturally expected. It is only one instance out of so many in which diseases distinct enough in their typical forms are prone to blend with others which trespass on their confines.

Perhaps the principal cause of neglect of the study of hysteria is the generally accepted fact that its attacks are hardly ever of a dangerous character. This, however, requires some qualification. Certainly death, either as a direct or indirect result, is exceedingly rare, although it appears that even this fatal effect has been induced in some instances by exhaustion. But an evil worse than death occasionally waits upon hysteria. It is not difficult to understand that the mind rather than the body may at length succumb to violent and oft-repeated attacks. The mental faculties being thus weakened and disordered, hysteria sometimes leads to insanity.

To enumerate all the diseases which are liable to be simulated by hysteria would be to furnish an almost complete nosological table. "This disease," Sydenham wrote, "is not more remarkable for its frequency than for the numerous forms under which it appears, resembling most of the distempers wherewith mankind are afflicted. For in whatever part of the body it be seated, it immediately produces such symptoms as are peculiar thereto." Leaving out of consideration here those which fall to the lot of the physician, such as peritonitis and paralysis, we may glance at the more prominent ones, the care of which devolves upon the surgeon. These will sufficiently illustrate others.

Disease of the spine.—A young woman will complain of pain in the back, with weakness of, and perhaps pain in, the lower extremities. Often there is a sense of constriction in some portion of the trunk, with occasional spasms. There may be even paralysis, accompanied with a difficulty of voiding the urine. When the spine is examined, it will be found to be acutely tender. A more careful examination, however, will probably discover that the pain is not confined to one portion of the spine, but extends to different regions, and is inclined to vary in position. Moreover, the tenderness is excessive and superficial, so that the patient flinches and complains more when the skin is pinched than when the vertebræ are pressed. And it should be borne in mind that most persons, more especially women and children, will start or shrink when sudden, although comparatively slight, pressure is made for the first time in the lumbar region of the spine; and this flinching, as Skey points out, is much more considerable if at the time of the examination the body be unsupported in front. Then, although the disease may have existed some time, there is no corresponding constitutional disturbance. The normal condition of the body is maintained. There is no wasting; no defect of nutrition. All this occurring in a young woman, in whom probably the circulation is weak, with some disorder of the uterine or other functions, stamps the disease as hysterical.

Disease of the joints.—A girl will complain of severe pain and tenderness in the knee. The joint is fixed and immovable,

and any attempt to move it elicits loud cries. But the tenderness, as in the last case, is excessive and superficial, so that she complains more when the skin is touched than when the heel is pressed upwards. There is frequently, too, a tendency to spasm; but this is different from the painful and involuntary startings of the limb at night in the real disease. Often also the leg is fixed in the extended position, whereas in real disease of the joint it is usually bent. However, to this rule there are abundant exceptions. The joint does not undergo any material alteration in size and shape, although there is often some degree of fulness—a puffy swelling. In some cases the enlargement may be considerable; but when this occurs, it is due to some local applications which have been previously employed. The joint, and indeed the whole limb, is very subject to frequent variations of temperature. "Thus, in the morning the limb may be cold, and of a pale or purple color, as if there were scarcely any circulation of blood in it; while towards the afternoon it becomes warm, and in the evening is actually hot to the touch, with the vessels turgid and the skin shining." Moreover, there is always a sense of weakness in the limb, which, after a while, is partially due to the condition of the muscles consequent on their inaction. Then there is the absence of constitutional symptoms. Although the sleep may be disturbed, and the patient watchful, there is not that almost entire absence of it which is so serious a feature in destructive disease of the joint. There is here a sufficient proportion of sleep for the necessities of the system. All this having existed without any material alteration for some time, with perhaps evidence of general debility or some local disturbance, proves the affection to be hysterical.

Or the hip-joint may be affected. There is pain in the hip and knee, aggravated by pressure and motion, and the patient lies fixed in one position. But here again the pain is diffused and superficial. Then time effects no real alteration in the condition of the limb. The investing muscles do not waste. There is no flattening of the nates. There may be unusual fulness about the joint, leading for a time to a suspicion of abscess. Sir B. Brodie observes that it is not uncommon to find much alteration in the figure of the parts. The pelvis may project posteriorly at the same time that it is elevated towards the affected side, so as to make an acute angle with the column of the vertebræ. Under these circumstances the limb is apparently shortened, so that when the patient stands erect the heel does not touch the ground. This strange distortion, due to the predominant action of certain muscles, assisted by the long-continued unnatural position, must not be confounded with dislocation. These affections of the joints sometimes terminate in remarkably sudden recovery.

Disease of the mammary gland.—The breast of a young woman is very painful and tender, and there is probably an unnatural fulness and tension of the entire gland, obvious when contrasted with the opposite one. The skin may have a glossy aspect, but the surface is very pale; or perhaps here and there ill-defined portions of the gland appear somewhat more indurated than the rest. These symptoms, especially the last mentioned, are very much aggravated by repeated handling, to which, unfortunately in these cases, the breast is continually subjected, so that often the suspicion of some tumor is excited, by which matters are made infinitely worse, inasmuch as it leads to repeated and prolonged examination. In these cases the true diagnosis is usually confirmed by the condition and history of the patient. There is commonly clear evidence of a feeble circulation and general debility, very frequently associated with some irregularity or other disorder of the uterine functions. Often, too, there have been previously some decided symptoms of hysteria.

Retention of urine.—A patient declares that she is unable to void her urine; that she has no power over her bladder. The bladder may be distended even to an abnormal extent, and yet the urine is retained. The absence of all local causes, the healthy condition of the urine, and the character and history of the patient, generally remove all doubt of the nature of the case. If the bladder be artificially relieved, the evil may be indefinitely prolonged. On the other hand, continued retention may lead to chronic inflammation or paralysis. These untoward results are, however, comparatively very rare. The patient, if left to her own resources, usually discovers before very long that the power has returned.

Local pain.—Pains of every kind and degree of severity, affecting any and, in succession, every part of the body, are common enough in hysteria. One of the most frequent and familiarly recognized has been called *clavus hystericus*. This is a pain in some one point of the head, which has been likened to the supposed effect of driving a nail into the part; hence the name. Its usual seat is immediately above one eyebrow. It is frequently more or less intermittent, and sometimes, when the paroxysms occur at regular intervals, it closely imitates the affection called brow-ague. Another very common seat of pain is the side below the mamma, usually the left. It is generally accompanied with acute tenderness, so that the person is unable to lie

upon it. It is sometimes described as a stitch in the side. It is often remarkably persistent. Complaint of pain in the hypogastric region is very common. In fact, "the processes of ordinary life, which in health are unfelt, are sensible and sometimes painfully so, to the hysterical patient." The character of the patient and her history generally declare the nature of the case. These and various other pains, more especially those in the head, are commonly described as amounting to excessive agony, and the subjects of them are very seldom at any loss in their description. Their imagination usually furnishes abundant similes and illustrations. It is not uncommon after a time to perceive in the part complained of a full and puffy condition of the integuments, accompanied with increased heat and perhaps some trifling vascularity. This immediately leads to the suspicion of abscess, and that after all the diagnosis was wrong. In truth, many of these cases are for awhile exceedingly perplexing, and sometimes it is impossible to establish at once a clear and satisfactory diagnosis. Chronic abscesses are often very insidious in their progress, and, at their commencement especially, most obscure. On the other hand, these local hysterical affections sometimes occur in those in whom they would be least expected to arise; in whom, perhaps, no other evidence of hysteria is, for the time, apparent. The diagnosis of these pains is sometimes still further complicated by the fact that they may have supervened upon some injury, which perhaps was trivial, but which may be described as severe.

But, instead of being thus unduly exalted, the natural sensibility of a part may be variously perverted or completely lost. And these disorders are not limited to ordinary sensation, but affect the special senses also.

Inequality and local variation in temperature are not uncommon.

And the same remark may be extended to the affections of voluntary motion. Every variety occurs, from violent convulsion or spasmodic contraction of a limb or muscle to complete paralysis. And often two or even more of these disorders coexist, so that it is easier to imagine than to describe the innumerable forms and varieties of local hysterical affections.

It may be well to review for a moment the chief points which should be borne in mind in the diagnosis of hysterical affections.

In the first place, the subject is generally a young woman, in whom, perhaps, the functions of the uterus or of some other organ have been for some time and are disordered, and in whom hysteria may have been already manifested in some of its more regular forms. Yet it would be a grave error to suppose that local hysterical affections do not occur in subjects who present none of these conditions. They are incidental to women even in advanced periods of life, and in whom no error of function can be elsewhere discovered. Nay, they are sometimes witnessed in the opposite sex, and I venture to think more frequently than is commonly imagined. Young men, the subjects of excessive mental or bodily fatigue and prostration, not unfrequently exhibit local affections which cannot in any way be distinguished pathologically from those which are called hysterical. Every form of disease and infirmity is, in turn, supposed to exist, and abundant evidence is furnished of the accuracy of Aristotle's observation, that melancholy persons are most ingenious. Such cases are often termed hypochondriacal; but when hypochondriasis is employed in this sense, it appears to me to become synonymous with hysteria. Indeed, Sydenham and others have considered hypochondriasis as a modification only of hysteria, the difference depending merely upon sex. Certainly they are connected by all their main features, and it is more than difficult to say in what essential points they differ. Nor are local hysterical affections always preceded by hysterical paroxysms. To assume this would be as grave an error as to suppose that these local forms are always cases of voluntary deception. No doubt, in the majority of cases, careful inquiry and examination will elicit some other evidence of hysteria either past or present. But to this rule there are many exceptions, and the surgeon who relied upon it in his diagnosis would be led too often seriously astray.

Then, although the affection may have existed—and it usually will last—for a considerable time, there is no commensurate impairment of the general health and strength, such as is produced by organic disease. The contrast between the local symptoms and the general mischief always furnishes most important evidence.

A careful cross-examination of the local symptoms will generally elicit some contradiction or inconsistency. For instance: the pain and other symptoms are often remittent or intermittent, not steady and abiding. The pain is often superficial; in fact, integumental, and very prone to be widely diffused beyond the supposed seat of mischief. Moreover, although after a time there may be some slight alteration in the size and shape of the part, there is never that decided and peculiar change which is, sooner or later, the inevitable result of certain local diseases.

Chloroform [or ether] is often of invaluable assistance in the diagnosis of hysterical

affections; for instance, in a case of contraction of a limb. When the patient is fairly under its influence, she can neither complain nor resist; and the ease with which the limb can be then extended, its perfect mobility and natural condition, proves the affection to be simply a fault of volition.

But the difficulty of diagnosis is incalculably increased when hysteria supervenes upon some real disease. Ordinary symptoms then become exaggerated, and the cause of their origin is apt to be overlooked in their obvious association with hysteria. Close and continued observation will at length resolve the doubt. In some of these cases chloroform [or ether] will remove the difficulty. But such a combination is comparatively rare. Hysteria generally disappears before real disease.

Finally, hysteria is far more frequently mistaken for real disease than real disease for hysteria, not only because it appears so curiously disguised and is so prone to simulate other diseases, but also because it so commonly occurs.

Sydenham affirmed that hysterical disorders "constitute one moiety of chronic distempers;" and this statement is indorsed by Connolly. Brodie says: "I do not hesitate to declare that among the higher classes of society, at least four-fifths of the female patients, who are commonly supposed to labor under diseases of the joints, labor under hysteria, and nothing else."

So variable in aspect, so inconsistent in character, hysteria mocks all attempts to define it, and seems to defy every endeavor to explain its pathology. Yet thus much appears clear and certain,—it is essentially an affection of the nervous system.

It is well known that the common office of the nerve-centres is that of variously disposing of the several impressions that reach them through their afferent nerve-fibres. Thus if communicated to motor fibres, reflex movements are produced; and the reflection may be confined to a single nerve, or it may radiate amongst several. In the one case, the result may be the contraction of a single muscle; in the other, the whole body may be agitated.

Or an impression conveyed to a certain portion of a nerve-centre may be transferred to other parts. Thus what have been called sympathetic pains arise. For examples: pain in the knee in disease of the hip; pain in the shoulder in affections of the liver. But, like reflection, this transference may be limited or diffused. In the latter case a local irritation may produce widely extended effects. A familiar example is presented in toothache; the pain sometimes spreads over both jaws and the face.

On the other hand, impressions producing like results may be transmitted from the brain to the other nerve-centres.

As the rule, in health, the effect produced varies:

1. As the intensity of the impression. This is commonly obvious, and it is strikingly illustrated in the ganglia of the sympathetic. For instance, the ordinary stimulus of food in the intestines conveyed to the ganglia is simply reflected and produces contraction of the canal. But if from the character of the food or otherwise, the stimulus be increased, the stronger impression is conducted from the nearer to the more distant ganglia, and more widely diffused and vigorous contractions result. Or the irritation being yet greater, the impression may reach the cerebro-spinal centres, and radiating thence, produce various pains and contractions, such as cramp.

2. According to the condition of the nerve-centres. Thus the same impressions will produce very different effects in different persons. Irrespective of the power of endurance, one person feels pain more acutely than another, and even in the same person the susceptibility varies at different periods of life. This is shown by the comparative facility with which convulsions are excited in children. An amount of irritation which in the adult would fail to produce any visible effect, will often in the very young, in this way, prove fatal. A familiar example is seen in the effects of "teething."

If, then, from any cause the irritability —that is the susceptibility to impressions— of the nerve-centres be in any way affected, it follows that the effect of any impression conveyed to them will vary proportionately. So, according to the condition of the nerve-centres, the effect of any impression may be exalted or diminished, or otherwise perverted. This, it may be reasonably assumed, is the key to the interpretation of the pathology of many affections of the nervous system, and amongst them of hysteria.

The particular form which the morbid action will acquire depends, doubtless, upon the seat and nature of the change. No wonder that this change is generally too subtle for our scrutiny, seeing that it may be due simply to the quantity or quality of the blood in the part or to the rapidity of its circulation.

Nothing is positively known of the exact condition of the nerve-centres which predisposes to the production of hysteria. It may be sometimes due to a defect in their original construction, but probably they are far more frequently enfeebled subsequently. It is, almost as a rule, associated with some form of debility of the system, or defect in the general health; and this, connected

with its variable manifestations; its sudden access and disappearance, often as the result of some forcible impression on the nervous system; its cure by means which improve the health and strength; and the absence of any discoverable lesion or defect after death, dissection affording only negative evidence—seem to connect the affection with the quantity and quality of the blood supplied to the nerve-centres, in a word, with their nutrition. That a defective condition of the blood or its circulation should be primarily manifested in these organs, is the result of the fact that no other organs are so immediately dependent on a healthy supply.

The nerve-centres being thus predisposed, a very trivial impression will be sufficient to excite the local or general phenomena of hysteria. The exciting cause may be either some abnormal state of any organ producing irritation, or the disease may have its origin in a nerve-centre. In this way the emotions may be supposed to act.

Thus the exciting cause of hysteria may be either of centric or eccentric origin. In the latter case there may be, as in epilepsy, an *aura hysterica*.

Brodie relates the following cases:

"An unmarried lady, thirty-two years of age, consulted me on account of her being liable to some very distressing paroxysms, in which she experienced a difficulty of respiration, attended with a sense of constriction of the chest, and great general excitement and agitation. These paroxysms often continued for ten or fifteen minutes, recurring at irregular intervals; sometimes without any evident cause; while at other times they might be traced to some sudden emotion of the mind. So far the case did not differ from many other cases of hysteria; but the peculiarity of it, and the circumstances which led to my being consulted, was as follows: There was a particular spot near the ensiform cartilage, which she believed to be in some way or another connected with her complaint. Nothing could be discovered in this part different from what is usual, by the most strict examination; but the pressure of the finger on it never failed to induce one of the paroxysms which I have just described. When these paroxysms were most severe, they were always attended with an abundant flow of limpid urine. These symptoms had existed in a greater or less degree for ten or twelve years, and had supervened on a state of exhaustion occasioned by an attack of typhus fever.

"A young married lady, who was liable to ordinary attacks of hysteria, complained of a tender spot on the anterior part of the abdomen, a little below the ensiform cartilage. The slightest pressure of the finger on it caused excessive pain, and was followed by violent agitation of the whole person, bearing a more near resemblance to the convulsive motions of chorea than to anything else and continuing for several minutes."

Viewing hysteria in this light, it is easy to understand its common association with disorders of the uterine functions; an association so frequent, that by many it has been, and is still believed to be, constant, as the derivation of the word implies. That the local irritation should be so frequently connected with the generative organs is what would be naturally expected from a consideration of the nature of their relation to other organs through the nervous system—their extensive "sympathies;" the powerful and active causes of excitement, and numerous disturbances to which they are subjected. But there is ample evidence to show that the exciting cause may be elsewhere, as for instance, in the intestinal canal, and act quite independently of the generative organs.

For the same reason it can be understood why hysteria so commonly occurs in women, seeing that the organs of generation, from their nature and influence, are so liable to prove an exciting cause, and that the system generally of women is, as a rule, so much more impressible than that of men.

But, as would be expected in this view of it, hysteria does sometimes, though comparatively seldom, occur in men; although in them the general symptoms of hysteria rarely become paroxysmal. They usually assume the features of hypochondriasis, which, if not identical with hysteria, is yet so closely allied to it, that the one passes by insensible degrees into the other.

Nor is it difficult to understand how hysteria may supervene upon some local disease which may act as its exciting cause. Thus hysteria may be set up by a wound or tumor.[1] On the other hand, but more rarely and obscurely, a local hysterical affection may lay the foundation of organic disease.

The influence of the mind upon the body is a subject well worthy of the most attentive consideration. If every one were familiar with the striking effects which may be produced by a steady and continued concentration of the attention upon a part of the body, we should hear less of the frauds and follies attributed to "animal magnetism," and of some other deceptions. Hysteria remarkably illustrates the powerful influence of emotions upon both body and mind; and more especially when it occurs, as it sometimes does, in imitation as it

[1] On this "Reflex Hysteria," see the essay on DISEASES OF NERVES.

were of a paroxysm witnessed in another. It has been often remarked that one hysterical patient in a ward will sometimes produce many more.

It is worthy of note, that in hysteria, more especially in its local forms, the effect produced, leading at length to some change or disturbance in the part, may react upon the susceptible nerve-centres, and thus aggravate materially the existing mischief. It is said that the liability to the hysteric paroxysm bears an exact ratio to its past frequency.

It is sometimes very difficult, if not impossible, to diagnose between hysterical and neuralgic affections on the one hand, and hysterical and feigned diseases on the other. And although in its typical and more common forms hysteria is sufficiently distinct from either neuralgia or voluntary simulation of disease, yet extreme cases are met with by which it appears to merge into one or the other. As a distinctive character between hysteria and neuralgia, it may be said that in the latter the cause of the mischief is always somewhere in the nerve or nerves between the seat of pain and the centre inclusive. Although contrary to the opinion of some, I venture to think that cases of voluntary deception should be separated from hysteria. In practice this may not be always possible, but pathologically the distinction appears to be clear; and to include them under a common term can lead only to confusion.

Still more difficult is oftentimes the diagnosis between hysterical and what are called sympathetic pains; for in either case the cause is perhaps some local irritation acting through a nerve-centre. After all, the chief means of distinction here must lie in the proportion between local cause and effect. Can it be assumed that the local mischief or disturbance, whatever it may be, is in itself adequate to account for the result? If not, is there then, so far as can be ascertained, any additional evidence of undue irritability or increased susceptibility of the nerve-centres which will explain the exaggerated effects?

The management of a person in a fit of hysteria is a very simple matter. Beyond placing her out of the way of mischief, on a bed or couch, perhaps the less that is done the better. Many of the plans of treatment which have been recommended are certainly injurious. It is doubtful if any of them are beneficial. Above all, no restraint should be imposed upon the patient, excepting such as appears to be absolutely necessary for her safety. It seldom happens that she seriously injures herself. Of this there is much less real than apparent danger. The subsequent exhaustion is generally very trifling; there is apparently a curious disproportion between this and the violence of the paroxysm.

In the treatment of hysteria, besides those general measures which are calculated to correct the morbid disposition of the system, special remedies are usually needed to remove the exciting cause. This, in a cursory inquiry, is very likely to be overlooked, as it is often subtle and obscure. It is especially liable to escape notice because commonly connected with some disorder of those functions which, being in more immediate relation with the ganglia of the sympathetic system, are frequently not revealed by direct and obvious symptoms. Yet it is always very important, and often essential, that the exciting cause be detected, and this a close and careful investigation will usually disclose. Then, beyond regarding the condition of the system generally, the state of every function should be particularly examined, more especially those of the uterus, the disorders of which prove to be so frequently the immediate exciting cause; and whatever is discovered to be wrong, either there or elsewhere, must be treated accordingly.

In investigating the nature of any local affection, with the view of determining its relation to hysteria, the condition of the part affected should be carefully examined in the first place—and this, if necessary, with the aid of chloroform [or ether]—in order to discover if there exist any equivalent cause for the evil complained of. Failing in this, the investigation should be carried along the course of its nerves to their centre; and no evidence being obtained of anything unnatural, the state of all the organs should be successively examined. Then the condition of the system generally in regard to the health and strength, not of the body alone, but of the mind also. And lastly, the previous history and present habits of the patient.

Certain applications are often beneficial in temporarily relieving local pain, such as lotions or ointments of aconite, belladonna, or opium, or injections of morphia. But there is one grand objection to all of them. They become the means of continually directing attention to the part, and of magnifying the importance of its symptoms. The temporary relief of pain frequently fails to counterbalance these evil effects. This objection, however, does not apply so forcibly to the application of plasters; and it is often an excellent plan to cover completely the part with some plaster spread on leather or moleskin, and not to allow it to be exposed or touched so long as the plaster will adhere. Thus the great evil of repeated examination is prevented. In hysterical affections of the breast, for instance, this kind of local treatment is eminently serviceable.

In the case of muscular rigidity or contraction—as, for example, when the leg is drawn up towards the thigh—when with the aid of chloroform [or ether] relaxation has been effected, and the part has been restored to its usual position, it sometimes proves useful to retain it so by means of a splint or otherwise, so that when the patient recovers we are able to appeal to the fact as an unanswerable confirmation of the truth of our conviction respecting the nature of the case. If this plan be not adopted, it is curious to witness the gradual return of the part to its previous condition so soon as the effects of chloroform begin to subside. And even after the artificial restraint has been continued for several days, as a rule the same relapse immediately follows its removal.

But these obstinate and enduring local affections can be satisfactorily treated only by general measures. The difficulty of effecting a cure sometimes appears to be almost insuperable; and this not so much from failure of the means employed, as from the extreme difficulty in many cases of enforcing their application. And this difficulty is complicated when the exciting cause has its origin in centric disturbances, as mental emotions. For in this case it is too often placed beyond our control. Nevertheless, this we must endeavor to reach if possible; but failing, the attempt should be made to direct the discharge or expenditure of emotion through another and more natural channel; as, for example, in active exercise. This is more practicable than attempting in the first instance to suppress its effects, for in a mind unaccustomed to discipline this is not easily accomplished. The worst fits are those which supervene upon intense efforts to suppress strong emotions. Carter says, "It may be taken as an invariable rule, that the paroxysm will be violent in exact proportion to the length of time during which the feelings giving rise to it have been concealed." In these cases, certain of the nerve-centres may be fairly described as in a state of extreme tension, and the discharge of nerve force through one or other of the various channels by which reflex actions are ordinarily manifested, seems in numerous instances to afford natural and safe relief. As previously stated, when the affection is voluntary on the part of the patient, when it is a case of wilful simulation, then it passes beyond hysteria. But there are some cases—and these are the most perplexing—in which, from long-continued disuse and want of effort, the will has lost its due control over the emotional influences. The most common cases are "those in which the occurrence of the fit, although not volitional, is yet a matter of surrender, and might be prevented under the pressure of an adequate motive."

Beside the adoption of all those hygienic measures which are adapted to improve health and increase strength—and it must not be forgotten that debility diminishes resistance to emotional as well as to other influences—a vigorous and persevering attempt must be made to erase all vicious habits and to remove all baneful influences. In order to succeed, the surgeon will need the aid of those whose consistent co-operation it is often most difficult to secure. Friends frequently fail to perceive the necessity of a plan of treatment which otherwise appears to be harsh and cruel. Matters are very often made worse by yielding to that desire for sympathy which is so urgent and universal.

As the rule, hysteria will be found to be engrafted upon some form of debility, and this, in many cases, is the result of the kind of life these patients have led. Hysteria is one of the many penalties imposed upon idleness. It will be too often found upon inquiry, that while the functions of neither the mind nor the body are ever exerted or even fairly exercised, the emotions uncontrolled are continually subjected to unwholesome excitement.

[In the following note it is the purpose of the writer briefly to consider the pathology, diagnosis, and treatment of hysteria more especially in reference to the requirements of the surgeon.

It is highly important to study the pathology of hysteria to such extent as to learn the nature of the disorder, rather than to enter upon any elaborate account of its symptoms.

These latter may appear in almost any modification of the action of the sense-organs, whether of the skin or of the organs of special sense, whether sensibility is abnormally augmented or is abnormally blunted, or is simply changed in quality. It may appear in almost any possible modification of function of the muscles, or in modifications of the action of most, if not all, of the secretory organs of the genito-urinary apparatus; in the spheres of the appetites, propensities, emotions, or in any part of the entire field of mental operations. The particular symptoms, therefore, or groups of symptoms, that have been or may be observed in cases of hysteria, it would be practically alike impossible and useless to enumerate.

After study of the whole subject, the following views in regard to the nature of hysteria appear to be clearly justified.

1. Hysteria does not include necessarily local disease, though frequently in complicated cases such disease is present.

2. It always includes, in general terms, a degree of nervous excitability above the average of health. The nervous system is

more easily impressed, either in part or as a whole, than it should be when healthy.

3. The hysterical individual has an unhealthy degree of emotional excitability.

4. Reflex excitability of the nervous system is, as a rule, exalted above a normal degree. This extends into the spheres of the musculo-motor, the vaso-motor, the secreto-motor and other divisions of the nervous system.

5. Finally, there is a lack of power in, or an exhaustion of, control centres, in the brain. *Inhibitory* and co-ordinating power in the brain is weakened or practically lost.

6. Certain of these conditions may be congenital or acquired.

In short, the principal and essential factors of hysteria are a morbidly sensitive condition of the nervous system, both sensorial and emotional, exalted reflex excitability, especially as regards the vaso-motor nervous system, so as to provide in this way for a tricky or explosive blood circulation in the brain and cord, and other parts, and finally a loss of inhibitory power by certain parts of the brain over spinal and, most marked of all, certain cerebral reflexes, as they are stimulated either by way of the peripheral nerves, or from the sensitive or exciting or excitable zones of the brain above.

There are no phenomena of hysteria pure and simple, which may not be subordinated to one or more of these categories or conditions. There are complicated cases, of course, in which a careful analysis would bring out other morbid conditions, not characteristic of or belonging to hysteria, that could not be subordinated to the comprehensive heads laid down in the above scheme. The disorders with which the surgeon meets, in which hysteria plays a prominent part, are hysterical paralysis, hysterical contractures, hysterical affections of the joints, and a variety of other less common disorders, such as simulated affections of the genito-urinary apparatus, etc.

It may be truly said, however, that hysterical affections of the muscular system and the articulations comprise nearly all the cases of especial interest to the surgeon.

In hysterical paralysis there are certain points, which, if remembered, will enable the surgeon as a rule to make a practically accurate diagnosis.

In the first place, this form of paralysis occurs in the female subject, as a rule, or in persons having a highly neurotic temperament. In every instance a careful inquiry into the history of the case will reveal an undoubted hysterical element, as evidenced by other symptoms than those involved in the paralysis. A close examination will show usually that the paralysis is variable, sometimes apparently complete, at other times manifestly not so.

Electro-muscular excitability, whether to the galvanic or the induced currents, is not diminished, but on the contrary, may appear to be increased; but it never rises to the height or presents the peculiarities exhibited at some stage in their course in paralyses dependent upon disease of the nerve-trunks, or of the anterior horns of gray matter in the spinal cord, as happens in the "degeneration reaction" of Erb.

Then, again, hysterical paralyses are almost invariably accompanied from the first by muscular contraction, or, at least, by more or less rigidity, especially of the flexors. This may be said never to make its appearance early in paralyses which depend upon disease of the nerve-trunks or of the anterior horns of gray matter in the spinal cord. Contractures do appear, however, in the later histories of paralyses of cerebral origin, or even in those depending on lesions of the motor nerves, or in cases of disease of the lateral columns of the spinal cord, but usually not until after a variable period of time has passed, that is, some weeks or months from the beginning of the paralysis.

In paralysis depending upon hæmorrhage into or lesion of certain parts of the brain, there are frequently associate movements, as in sneezing or yawning, or in vigorous use of the corresponding, non-paralyzed member. These do not occur, or if at all, rarely, in hysterical paralysis.

Again, it is exceedingly rare for notable changes to occur in the sensibility, as, for example, for anæsthesia to appear in the skin of the paralyzed member, depending upon serious organic affection of the nerves and central nervous system. It is the rule, however, for disorders of sensibility to appear in hysterical paralysis.

Furthermore, there is, for instance, in hysterical hemiplegias, an apparent diminution in reflex excitability of the paralyzed leg or arm, that may be said never to exist in paralysis depending upon active organic disease of the brain.

In connection with such points of distinction between hysterical and other paralyses, the whole history of the case must be taken into account. Under such circumstances, it is hardly possible for a wary surgeon to be finally in doubt.

Next, as regards hysterical contractures. These disorders, perhaps, are more frequently brought to the attention of the surgeon than any others. He is consulted with the view of restoring to use a contracted member by dividing the tendons of its contracted muscles.

The means for making a diagnosis are, in part, the same as those already referred to in the discussion in connection with hysterical paralysis.

There are three forms of disorder with which it is possible to confound that now under discussion:

In the first place, it may be confounded with the contractures that arise in the course of amyotrophic, lateral sclerosis (Charcot, *Spastic paralysis* of Erb); or it may be confounded with the apparent but not real contractures, met with when the extensors are paralyzed, and when, in consequence, a limb is given up to the unrestrained action of its flexors; and, in the third place, it may be confounded with what may be called *essential contractures* (Straus), which result from acute myositis, and in which the muscles undergo extensive changes, and finally recover with more or less destruction of true muscular tissue, interpenetrated throughout by connective or cicatricial tissue.

The means for distinguishing hysterical contractures from other forms just alluded to, are happily clear. In the first place, the history of spastic paralysis or *amyotrophic lateral sclerosis*, followed by contracture, seldom occurs in the hysterical person. In the second place, there is almost never an involvement of the sensibility of the contracted member, in spastic paralysis. There almost always is, on the contrary, in hysterical contracture. Reflex excitability of the contracted member as a rule is greatly augmented in spastic paralysis. In hysterical contracture, such is not the case, but rather the opposite, and finally, under the influence of anæsthetics, hysterical contractures usually give way entirely; not to the same extent those which belong to spastic paralysis.

As regards the contractures which depend upon paralysis of the extensors, there is, as a rule, no involvment of sensibility. There is diminished electro-muscular excitability in this class of contractures in the extensor muscles. Not so in hysterical paralysis.

As regards essential contractures, it is to be said that the histories of the cases are found usually to be clearly different, especially in the following particulars, that is, essential contractures occur usually in the male sex, hysterical contractures generally in the female. Essential contracture usually arises in the course of serious local injuries or local disease, as in the wake of burrowing abscesses, or extended local inflammations of various kinds involving a muscle or group of muscles, and these become the seat of acute disease, and, as a sequel, the structure of the muscles is spoiled or destroyed, and a cicatricial shortening is one of the results. Such, it is needless to say, is not the course of hysterical contracture. In essential contractures the muscles often utterly lose their susceptibility to both the galvanic and induced currents, and essential contractures are not relaxed, for manifest reasons, under the influence of an anæsthetic or during sleep.

It is hence possible to distinguish hysterical contractures from those arising from other causes, by well-defined diagnostic symptoms.

As regards hysterical joint affections, the cases are frequently not so easy to classify. There are at least two classes of joint affections, clinically speaking, in which the hysterical element plays a conspicuous part.

In the first place there is the pure hysterical joint affection, in which there is found no swelling, no abnormal heat, no discoloration, no change in the sweating or other conditions of the affected part. There is, however, excessive complaint on the part of the patient of pain, of inability to permit the tender joint to be handled or used.

There is, next in order, the mixed case, in which the hysterical element, as in the first-mentioned case, is present, but in which, at the same time, there is actual disease of the joint, rheumatic, gouty, a spinal arthropathy, etc. The joint is swollen, its temperature is raised beyond the normal. But the hysterical element is present, simultaneously with the actual local disease, to exaggerate and apparently to prolong it. Long after the real local disease has subsided, the individual has pain upon the slightest movement, is unable to permit the member to be used or handled, and thus becomes a distressing invalid.

If a case of alleged joint disease should appear in a nervous female with decided hysterical tendency; if the joint complained of should be either not swollen, or if so, the complaint should be entirely disproportioned to the character of the disease, there would be reason to suspect at least a hysterical complication, and plain warrant for taking somewhat summary measures for its relief.

Such are the principal affections, partly or completely hysterical, with which the surgeon is likely to meet.

There are other affections which the surgeon is called upon to treat in which hysteria plays an important part, but these have been considered perhaps with sufficient fulness in the article to which this note is appended.

As regards the treatment of hysteria it is difficult to speak in a definite manner, except in so far as curative means are dictated *a priori* by its true pathological conditions. As already said, hysteria pure and simple does not depend necessarily upon any serious local disease of the nervous system. It refers rather to an improperly developed nervous system in which its

higher parts or those for domination or control are relatively weak, especially when the nervous system is exhausted. It implies side by side with these first conditions exalted reflex excitability. There is therefore a loss of equilibrium between the tendency or capacity toward reflex action and the power of inhibition, or of control, and with this a highly fluctuating blood circulation. The nervous system is to a morbid degree given over to reflex activities. In spite of a disposition to the contrary, acts are performed, and mental states arise, which the will of the individual is powerless to control, except under the stimulus of unusually powerful motives. Under these circumstances it is necessary for the wary and careful surgeon to determine as nearly as possible what under the circumstances he ought to do, and to see that it is done. The whims, or even the solemn convictions of the patient as to what can be done or endured should be ignored in the presence of conclusions reached as the results of conscientious study of the conditions and needs of the patient. It is generally necessary to remove such patients first of all from the influence of relatives and personal acquaintances. They should be placed rather under the skilled management of those whose actions can be guided by the decisions of the surgeon, and not at all by the complaints or requests of the patient, unless these happen to be in a manifestly proper direction. Such patients must be taught, if need be by an outwardly rough and relentless discipline, that they can do or they can endure what they firmly believe cannot be done or endured. Unfortunate habits and mistaken notions must be broken up, or dissipated, if need be, without hesitation.

Such cases, it is well known, do not really require surgical treatment. As soon as their true nature is made known they cease to be, in appearance as well as in fact, surgical patients.

As regards the medical as well as the moral treatment necessary in such cases no fixed rules can be given. The course to be taken must depend entirely upon the good sense of the surgeon himself, because the morbid conditions which accompany hysteria differ almost as widely as possible.

In all cases, to some extent and at some period in their progress, tonics are required, especially those calculated to give a vigorous impulse to nerve-nutrition. Means to diminish reflex excitability of the nervous system in general are usually required. One of the most important general means for the improvement of such cases is that of massage practised in a thorough manner. In this article it is alike impossible and unnecessary to enter into this important phase of the treatment of surgical affections simulated in hysteria.

But by removal from the influence of friends sympathizing too deeply; by providing a skilled nurse; by firmly, yet kindly teaching the patient lessons of endurance; by breaking up settled habits of invalidism; by improving nutrition by due attention to the condition of the alimentary canal; by simple, though good feeding; by careful massage; by securing an abundance of sleep; by the use of light sedatives, and if needed, of anodynes and the cautious use of tonics; by daily exposure to fresh air and sunlight; by keeping the patient from exciting company; by due attention to local disorders that may happen to complicate cases; by such means are cases of the kind now under consideration to be slowly, but, as a rule, certainly benefited.

The principal recent works which may be consulted in the study of hysteria are:

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l'hyperesthésie hyst., Thèse de Paris, 1847. Macario, De la paralysie hystér., Annal. méd. psych., 1844. Szokalsky, Von der Anästhesie u. hyperästhesie u. s. w., Prag. Vierteljahrschr., 1851, 4 Bd. Lebreton, Des differentes variétés de la paralysie hystérique, Thèse de Paris, 1868. Brodie, Lectures Illustrative of Certain Local Nervous Affections, London, 1837. Stromeyer, Erfahr. uber Localneurosen, Hanover, 1873. Berger, Zur Lehre von. d. Gelenk-neuralgien, Berliner Klin. Wochens., 1873. Hirsch, Beiträge z. Erkenntniss u. Heilung der Spinalneurosen, Königsberg, 1843. Türck, Abhandl. üb. Spinalirritation, Wien, 1843. Eulenberg, Lehrbuch der Nervenkrankheiten, p. 697, Berlin, 1878. The reader may also consult the various monographs on nervous diseases.

PART V.

INJURIES OF REGIONS.

INJURIES OF THE HEAD.
INJURIES OF THE FACE.
INJURIES OF THE NECK.
INJURIES OF THE CHEST.
INJURIES OF THE BACK.
INJURIES OF THE PELVIS.
INJURIES OF THE UPPER EXTREMITY.
INJURIES OF THE ABDOMEN.
INJURIES OF THE LOWER EXTREMITIES.

PART V.

INJURIES OF THE HEAD.

By Prescott Hewett, Esq.,

Revised by John A. Lidell, A.M., M.D.

It has been thought advisable, for practical purposes, to treat of these injuries together, as they are often combined in civil life; and what appeared a simple wound of the scalp is ultimately not unfrequently found to have been complicated by much more serious mischief,—contusion of the bone.

[*Contusions of the scalp* present some peculiarities which require notice. (1) However severe the bruise may be it seldom sloughs. This circumstance is obviously due to the wonderful vascularity and consequent vitality of the cranial integuments. (2) Bruises of the scalp, owing to nearness of the underlying bone, are specially liable to be attended with rupture of bloodvessels, having considerable size and with correspondingly copious subtegumentary extravasation of blood. A slight blow suffices to produce an ecchymosis—a strong one a large swelling. (3) When the extravasation is very copious and rapid it sometimes becomes widely diffused. For example, in a case reported by the writer (Am. Jour. Med. Sciences, April, 1879, pp. 308–310), where, from a violent blow on the left temple, some large branch of the temporal artery was ruptured, the sanguineous effusion was not limited to the temporal fossa, but it burrowed behind the zygoma down to the insertion of the temporal muscle, thence followed the ramus of the lower jaw down to its base, and accumulating in the connective tissue beneath the angle and base, caused a great swelling to form in the left side of the throat, which interfered much with the act of swallowing for several days. This extravasated blood, however, was readily removed by absorption. (4) Scalp bruises involving the temporal muscle may be followed by atrophy of the bruised part of the muscle, as happened in the case just mentioned, whereby a cavity in the muscle itself was formed, which long after the accident might readily be mistaken for depressed fracture of the bone (*ibid.*, p. 312). (5) Scalp bruises in girls and young women have been known to be followed by severe neuralgia. In the case just mentioned, the patient, a robust man, aged 43, became the victim of such neuralgia as the bruised parts regained their normal condition. Treatment afforded but little relief. The pains, however, after continuing three months in full blast, gradually wore away and ultimately disappeared. Generally this form of traumatic neuralgia proves extremely rebellious to treatment; but incisions down to the bone are said to have sometimes proved beneficial.

(6) Scalp-bruises when produced by gunshot projectiles, and especially when produced by cylindro-conoidal bullets, are usually injuries of very serious import. Dr. Otis thus sums up the experience on this point of our army surgeons during the late war: "Gunshot contusions of the head without breach of surface, of sufficient severity to cause ecchymosis, were invariably attended by commotion, concussion, or intracranial extravasation" (Med. and Surg. Hist. of the War of the Rebellion, Pt. I., vol. ii., p. 93), and this statement fully accords with my own observations.

There is a deceptive condition of the scalp, the result of fresh contusion, which requires mention. It is not accompanied by much swelling, nor by the extravasation of much blood. In it the deep laminæ of the scalp are disintegrated and cut through, as it were, by the violence of the contusing force, while the external laminæ remain entire. The place of injury is soft in the middle, but its edges are hard and sharply defined, and a superficial examina-

tion is liable to impart to the sense of touch, the impression that the skull is fractured, and that a portion of it is depressed. On thorough examination, however, the surgeon can generally satisfy himself that the bone is not broken, and that it occupies a normal position. Mr. Erichsen states that he has occasionally seen this condition of bruised scalp in children whose cranial integuments are naturally soft and spongy; but the writer has met with it in adults, as well as in children.

When the sanguinolent swellings of the scalp, which are produced by contusion, suppurate, or their contents putrefy, they should be opened by the surgeon, and treated with antiseptic poultices, such as charcoal, etc.; but under no other circumstances as a rule should these bloody tumors be incised, since unhealthy, tedious, and troublesome suppuration is almost sure to follow. In exceptional instances, however, when these swellings have become very chronic and ceased to subside, they may be treated by puncturing under conditions which will be presented further on.

Of the various forms of scalp wounds occurring in daily life, wounds produced by heavy blows, or those in which flaps have been more or less extensively detached, are the most common. Such wounds are, for most part, accompanied by bruising of the soft parts; but it not unfrequently happens that these bruised wounds of the scalp present the appearance of a clean cut, and look exactly as if they had been produced by some sharp instrument. These flap wounds are more common about the scalp than in any other part of the body, and it is in this region, too, that the most extensive wounds of this kind are generally met with, the greater part of the skull being at times uncovered, and even the ears torn away.

Bruised wounds of the scalp are to be treated like common incised wounds, and in many instances they heal just as readily.

Neither is there, in the present day, any question as to what is to be done with flap wounds of the scalp. After careful cleansing of both surfaces of the wound, the flap, however extensive, is to be replaced, and maintained in position by strips of plaster, compresses, and a bandage. Sometimes a suture, here and there, may be necessary; but sutures must be sparingly used about the scalp, and great care must be taken not to include any part of the occipito-frontalis.

[Neudörfer, the celebrated Austrian surgeon, remarks, that when wounds of the scalp are approximated by adhesive strips, the lips are inverted, and the healing of the wound is long delayed by the ingrowing of the hair. On this account he greatly prefers to unite such wounds by points of suture. Hennen, Guthrie, and Liston sanction the employment of sutures in scalp wounds where there is much retraction of the edges. S. W. Gross, in a case where a large semilunar flap raised from the vertex and side of head presented a wound thirteen inches in length, approximated the edges by nine points of silver suture; on the fourth day union was perfect. "There can be no doubt that exaggerated apprehensions have been entertained with respect to the employment of sutures in wounds of this class." (Med. and Surg. Hist. of the War of the Rebellion, Pt. I., vol. ii., p. 15.) I am satisfied from much experience that sutures in scalp wounds are harmless, provided they are not left in long. When, then, a large flap of integument is detached from the head, it should be replaced and retained as nearly as possible in its natural situation by sutures, by strips of adhesive plaster, and by a supporting bandage. In many cases the interrupted suture can be employed with striking benefit; in some cases it is indispensable. Whenever the hair-clad edges of the wound incurve a good deal, which not unfrequently happens, much better results are obtained by holding the lips of the wound together with sutures put in at a sufficient number of points. When there is a long, flap-shaped cut, sutures are also very advantageous. Incised wounds of the scalp, especially when they are long and penetrate through it to the skull, are apt to gape widely on some parts of the head, from the elasticity of the injured structures and the looseness of the underlying connective tissue. In some cases of this sort the employment of interrupted sutures is indispensable. I have seen more than one example. At an early period in the after-treatment, *i. e.*, on the third or fourth day, or as soon as the lips of the wound are securely glued together, the sutures and ligatures should all be taken out, because their presence tends to prevent the occurrence of union by the first intention. The best materials for scalp-sutures are carbolized silk and silver wire; antiseptic dressings should be applied.]

Flap wounds of the scalp, of the largest size, are not unfrequently healed within a few days. Occurring, as most of these flap wounds do, by the rending of the loose cellular tissue under the occipito-frontalis, they carry with them a rich supply of bloodvessels; and hence the reason why these flaps so seldom slough, and why they so readily heal.

The bone of the skull being exposed makes no difference as to the plan of treatment; for flap wounds, with extensive exposure of the bone, often heal without a single drawback, and that in cases where such a result appeared almost hopeless.

The wound may, however, not heal by

first intention; and, under such circumstances, either granulations spring up from the surface of the exposed bone, or thin, almost imperceptible, scales of bone are thrown off, and union by second intention follows.

Hæmorrhage in scalp wounds is seldom very troublesome. Both ends of the divided vessel can, for the most part, be readily secured, or pressure may be established on the main trunk, at some distance from the wound. In a wound of the lower part of the temporal fossa, hæmorrhage from the deeper vessels may, however, be very difficult to deal with; and in such a case, should the bleeding recur and become dangerous, notwithstanding all our local means, the question of applying a ligature to the external or to the common carotid artery may arise.

[Among 331 cases of miscellaneous injuries of the scalp (not gunshot), that occurred during our civil war, "several instances of troublesome bleeding from the posterior auricular, occipital or temporal arteries, or their branches, are reported; but in every case the hæmorrhage was controlled by compression, either by the clamp tourniquet, or the common tourniquet, or by a circular bandage and compress, or a compress consisting of a metallic disk. In one case, a profuse secondary bleeding from the temporal was arrested by dividing the vessel transversely, and allowing it to retract. Persulphate of iron, in powder or solution, was employed as a styptic in several cases; but not with advantage. In a case in which it appeared that ligation must be resorted to, acupressure was suggested as peculiarly appropriate; and preparations to use this resource were made, when, the bleeding being controlled by pressure, ceased, and did not recur." (Op. cit., p. 64.)]

Wounds of the scalp, even of the most trifling nature, are not unfrequently followed by inflammation of an erysipelatous character, affecting sometimes the skin only, but much more commonly the loose cellular tissue under the occipito-frontalis muscle.

If erysipelas alone exist, the local treatment is to be of the simplest kind. The frequent lancet-puncturings, so strongly advocated some few years back, are not necessary; they are exceedingly painful, and they certainly do not lessen the duration of the disease.

Diffuse cellular inflammation of the scalp first shows itself by slight puffiness, without any redness of the skin, in the neighborhood of the wound; and this local indication, if not ushered in, is soon followed by general symptoms—feverishness and rigors. An outpouring of lymph subsequently takes place into the meshes of the loose cellular tissue, and then more or less induration and great thickening of the scalp, which, when cut into, presents a brawnlike appearance. Unchecked, this form of inflammation soon leads to extensive sloughing, and large portions of the cellular tissue are rapidly destroyed.

On the first appearance of puffiness around a scalp wound, a free exit should be given to the effused fluid, and for this purpose the adherent lips of the wound ought at once to be separated. In large flap wounds, however, it is seldom necessary to destroy all the adhesions; a free separation of the lips of the wound at different points is, in most cases, all that is necessary, and then a warm poultice or fomentations should be applied. Should the effusion spread notwithstanding, the system of free puncturing may be adopted with great advantage, and in the more threatening cases incisions will be absolutely necessary. In such cases, the essential point is that the knife should be carried freely down to the bone; and as to the length of the incision, it is better that it should not be extensive. Limited incisions answer every purpose; and they lessen the danger of hæmorrhage, which, in persons of broken-down constitution, may become a matter of vital importance.

Such incisions, provided the general condition of the patient be good, will, in the great majority of cases, prevent any very extensive sloughing of the cellular tissue of the scalp. In some cases, however, extensive sloughing of the cellular tissue does take place, and the tendon of the occipito-frontalis muscle and the pericranium may become involved; but the scalp itself very rarely perishes. This is easily accounted for by the peculiar distribution of the arteries in this region, the trunks and main branches of which here all lie immediately under the skin. And occasionally, to add to the difficulties, a large arterial trunk is laid open by ulceration, and hæmorrhage ensues, the source of which, owing to the blood accumulating under the detached scalp, it may at first be difficult to make out.

With proper management, it is surprising, notwithstanding all this, to see how well a case of this kind may do. The sloughs separate, but the extensively detached scalp, loose and bag-like, being kept alive by its vessels, soon re-adapts itself to whatever structures may be left, and ultimately becomes firmly adherent to them.

[Among the miscellaneous injuries of the scalp (not gunshot), that occurred during the war of the Rebellion, "Erysipelas was not a very frequent complication, being reported in but thirteen of the four hundred and three cases unattended by frac-

ture. Nearly all of the cases in which it supervened were attended by symptoms of affection of the membranes of the brain, or of the brain itself; yet, with one exception, they terminated favorably, under the supporting and stimulating treatment uniformly adopted. There were numerous instances of abscesses under the scalp, due apparently, in most cases, to negligence in keeping the detached scalp in apposition with the subjacent parts by gentle bandaging, or to the retention of clots of blood under the flaps. Incisions, followed by fomentations and poultices, and the washing out of the cavity of the abscess by warm detergent solutions, appears to have been the ordinary treatment. In many of the contused and lacerated wounds, there was slight loss of tissue from gangrene, and in two cases, very large portions of the scalp sloughed away, yet the exposed surface was soon covered with florid granulations, and rapidly cicatrized. Detergent or stimulating lotions were employed in these cases, and solutions of the salts of zinc or permanganate of potassa were the applications commonly selected." (Op. cit., pp. 64–657.)]

The general treatment, both in erysipelas and in diffuse cellular inflammation of the scalp, must be of the most generous kind. Tonics and diffusible stimulants must be resorted to at a very early period; and it will be advisable also freely to administer such stimulants—brandy, wine, etc.—as the patient may have been accustomed to.

Contusions of the Cranial Bones.

A simple blow on the head, with or without a scalp wound, may sooner or later lead to mischief about the bones of the calvaria. Sometimes the diseased action thus set up ends in hypertrophy of the bones; this may go on for years, and the calvaria thus become enormously thickened. Of this there is a well-marked example in the Museum of the Royal College of Surgeons. In the vault of this skull the bones are, in some parts, no less than eleven lines in thickness.

Again, the diseased action thus set up may lead to caries or necrosis of the calvaria. And here the disease may be limited to the original seat of the injury, or it may spread far and wide, affecting either one or both tables of the bones. In some cases even the mischief has spread over the whole vault of the skull. Specimens of extensive disease, limited to the outer parts of the calvaria, and caused by a simple blow, exist in the Museums of the Royal College of Surgeons and of St. George's Hospital. Dr. Abercrombie[1] mentions a case in which the inner table alone of the calvaria was thus extensively destroyed. In Norris's[1] case the disease attacked both tables of the whole of the calvaria, and extended even as far as the foramen magnum. The skull is now in the Museum of the Royal College of Surgeons.[2] Mr. Drummond's case[3] affords another example of extensive destruction of the vault of the skull, originating in a blow on the head. But of cases of this kind, Saviard's[4] is the most extraordinary. In this case, two years after a blow on the head, the whole skull-cap came bodily away.

[*Contusions of the cranial bones* present some important phenomena which require additional notice. 1. Not unfrequently the bruised portion of bone is suddenly deprived of vitality at the moment of injury, *i. e.*, it is killed outright by the blow, and then circumscribed necrosis of a primary character is produced. Quesnay (Mem. de l'Acad. Royale de Chir., T. I., pp. 209, 220, Paris, 1761) relates two such cases. In the American Journal of the Medical Sciences, Oct., 1879 (pp. 402–408), the writer published twelve analogous cases. Moreover, the Medical and Surgical History of the War of the Rebellion, contains brief accounts of many cases belonging to the same category (Part I., vol. ii., pp. 95–128).

In cases of osteal contusion it is probable that interstitial extravasation of blood always occurs, but ecchymosis is not discernible by the unaided eye unless the structure is such that the medullary spaces possess some considerable size, as for example, in the diploë of the skull, in the spongy tissue of the short bones, and in the epiphyses of the long bones. The compact osseous structures may be severely bruised without presenting an ecchymosed appearance. In the cancellous structure of bone, however, the writer has several times seen well-marked ecchymoses the result of contusion; and he published two examples thereof in the July number of the American Journal of the Medical Sciences, for 1865 (pp. 20–23).

Contusions sometimes kill the external table only and generally the external table is much more extensively destroyed than the internal.

Examples of primary necrosis, represented in the accompanying woodcut (Fig. 100), are taken, together with the history of the case, from the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p.

[1] Diseases of the Brain, 2d edit., p. 189.

[1] Trans. of the Med. Soc. of London, vol. i., p. 168.

[2] Pathol. Cat., 1847, vol. ii., p. 115. It is entered as a specimen of tuberculated syphilitic disease; but this is an error.

[3] Med.-Chir. Trans., vol. xxxiv., p. 103.

[4] Rec. d'Obs. Chir., 1762, p. 386.

123. The necrosed fragments do not exhibit any inflammatory change.

Fig. 100.

FIG. 100. Fragments from the left parietal that had been necrosed by the stroke of a bullet. *Spec.* 4178, Sect. I., A. M. M.

The natural size of the specimens is shown in the woodcuts (FIGS. 101, 102),

Fig. 101.

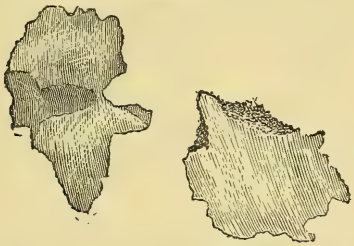


FIG. 101. Exfoliations resulting from gunshot contusion of the cranium. *Spec.* 4943, Sect. I., A. M. M. They do not exhibit any evidence of having undergone inflammatory changes in structure. They consist of two distinct fragments.

which were also taken from the same work as FIG. 100.

Fig. 102.

FIG. 102. Internal view of the last two specimens. One of them embraces the whole thickness of the bone; the other, the outer table and diploë only, and the diploë is shown in the figure. Neither of them exhibit any appearance of inflammatory change in structure.

2. Inflammation of a formative character is sometimes excited in the cranial bones by contusion. This pathological process bears a strong resemblance to certain physiological processes that occur in bone, and leads to increase of density, or *induration* (*osteo-sclerosis*, *eburnatio*) of the affected part, on the one hand, and to increase of thickness, or *hypertrophy* (*hyperostosis*, *periostosis*, *exostosis*) of the affected part, on the other. The first results from inflammatory irritation of the cranial medullary tissue; the other from inflammatory irritation of the pericranium.

A case of inflammatory induration of the skull (*eburnatio*), the result of contusion, is related by Quesnay (op. cit., p. 225).

Of three hundred and twenty-eight examples of gunshot contusions of the cranial bones that are mentioned in the Medical and Surgical History of the War of the Rebellion, "there were ten cases in which persistence of pain, either in the cicatrices or in distinct spots of the cranium, constituted the prominent symptoms. Three of them belong to the class of cases described by Quesnay. All of these patients were spared the incisions of the scalp or the application of the rugina or trephine; five recovered and went to duty, while five were discharged for disability, two of whom were subsequently pensioned" (op. cit., p. 127). Concerning sclerosis of the skull, Dr. Otis, the distinguished surgical historiographer of the war, further remarks: "The induration and eburnation of the outer table mentioned by Rokitansky as a consequence of contusion, was observed in six or seven of the fatal cases. It is very well illustrated in specimens 1568, 2523, and 3406 of the Surgical Section of the Army Medical Museum" (op. cit., p. 127).

Thus it appears that induration or eburnation of the skull not unfrequently results from contusion, and that the inflammatory process by which the osteal sclerosis is consummated is sometimes a very painful process. It is not improbable that many, perhaps a large majority, of the cases of cranial contusion wherein the patients have suffered great pain in the injured part of the skull, for long periods of time, without the coincidence of local suppuration, or exfoliation, or cerebral abscess, belong in reality to this category. In the Med. and Surg. Hist. of the War, under the head of "Miscellaneous Injuries" (not gunshot), is an example in point (Part I., vol. ii., p. 42).

Hypertrophy of the skull is produced by contusion in the following manner: The bruise excites non-suppurative inflammation of the pericranium, which manifests itself by augmenting the physiological activity of this membrane. According to the law of periosteal growth, successive layers of new bone are deposited underneath this membrane. Thus we get inflammatory *hyperostoses*, *periostoses*, and *exostoses*. But hypertrophy of the cranial bones, in consequence of gunshot contusion, does not often occur, according to Dr. Otis. The Army Medical Museum, however, contains three specimens which "are good examples of chronic thickening of the skull"

from bruises produced by blows or falls. They are specimens 5135 and 5481, section i., and specimen 55, section iv. (op. cit., p. 127, footnote). Mr. Stanley says: "I have known instances where a blow upon the head was followed by thickening with induration in the bones of the cranium. But these conditions of bone are mostly the effect of rheumatism." (Diseases of the Bones, p. 40, Am. ed.)

3. Destructive inflammation is often excited in the cranial bones by contusion, and *inflammatory necrosis*, *caries*, and *osteo-porosis* are produced thereby, with corresponding exfoliations of dead bone. Ollier says: "Inflammation does not affect the bone-cells proper, except secondarily; its first effects are produced on the marrow-canals, the osteogenetic layer of the periosteum, and the contents of the Haversian canals" (Am. Jour. Med. Sciences, January, 1868, p. 152). An instructive example of inflammatory necrosis of the skull caused by contusion is recorded by Professor Stephen Smith.

Professor Smith also quotes "a case reported in a Canadian medical journal several years ago, in which a large portion of the top of the cranium separated without any serious ill effects following."

Of 328 patients with gunshot contusions of the cranial bones that are reported in

Fig. 103.

FIG. 103. A segment of the os frontis, showing inflammatory necrosis following a gunshot contusion, which terminated fatally about three months after the casualty.—*Spec.* 2964, Sec. I., A. M. M.

the Medical and Surgical History of the War of the Rebellion, 37 had cranial exfoliations, and 5 of them died.

With regard to *caries* as a result of contusions of the cranial bones, the experience of our civil war shows that it but seldom

Fig. 104.

FIG. 104. Internal view of the same specimen, showing the diseased dura mater and the ulceration of the inner table.

These woodcuts are taken from the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 106.

occurs, inasmuch as it was met with in but four of the reported cases, one of them being classified under the head of "Miscellaneous Injuries." Dr. Otis says: "Gunshot contusions of the cranial bones were succeeded, in three instances, by caries. This complication, common enough in tertiary syphilis, mercurio-syphilis, and scrofula, rarely occurs as a result of injury, unless there is some constitutional taint. There is no evidence, however, that any such vice of system existed in the cases of which abstracts are subjoined. The energetic treatment advised by authors, such as applications of the rugine or trepan, the actual cautery, or chloride of zinc, red oxide of mercury, and other powerful escharotics, were not employed in any of these cases" (p. 106).

The experience of our army surgeons also shows that *cranial periostitis* is but seldom excited by cranial contusion, for it was observed in only a few instances from the beginning to the end of the war. Among 328 patients having gunshot contusions of the cranial bones, only 4 cases of pericranial inflammation are reported.

Osteo-porosis, or *medullization*, is a frequent consequence of cranial contusions, and sometimes is so well marked that the compact structures present a worm-eaten or honeycombed appearance, when examined after maceration.]

The treatment of such cases differs in no

wise from that of caries and necrosis of the skull arising from other causes. Matter pent up under the scalp must be let out, and the loose pieces of bone removed; and occasionally, but very rarely, the application of the trephine may become necessary. But in this we cannot be too cautious, notwithstanding the brilliant results obtained in former times by the extensive application of this instrument.

In the above cases, the mischief in the bone was chronic; but a blow on the head, with or without a scalp wound denuding the bone, may be followed by inflammation of an acute character, the starting-point of which is in the diploë, where the blow is followed by an extravasation of blood, or a breaking-down of the cancellous tissue; the compact tables suffering but little from the injury.

Suppuration of the Diploë from Contusion.

Inflammation of the diploë, in connection with such a contusion, is fraught with danger. The inflammation may at any moment spread to the internal table of the bone, and from thence to the membranes of the brain; and, involving some of the veins of the diploë, it may also lead to purulent infection, and to secondary deposits in various parts of the body.

The patient having recovered from the immediate effects of the injury, may for a time appear to be in perfect health; and thus matters generally go on for a fortnight or three weeks, when a change, slight at first, takes place. When there is a wound, it loses its healthy aspect, and this is accompanied by feverishness and pain in the head; then follows a spontaneous secession of the periosteum; and the bone, if denuded, becomes dry and discolored. Such are the first indications of mischief; and now, should the inflammation spread from the internal table of the bone to the dura mater, this membrane secedes from the affected bone, and its outer surface is covered with lymph or pus. Thus far the mischief is circumscribed; but when the inflammation reaches the parietal arachnoid, it spreads more or less over the free surface of this membrane, and soon involves the visceral layer of the arachnoid, the pia mater, and the corresponding surface of the brain. Meanwhile the symptoms become more and more marked—increased feverishness, repeated rigors, intense pain in the head, sickness, drowsiness, occasional wandering, coma, and sometimes paralysis.

[Illustrative cases, of more value than many pages of abstract description, may be found in the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 125; Am. Journ. of Med. Sciences, Oct., 1879, p. 415; Edinb. Med. Journ., Aug., 1873, p. 124; M. and S. Hist. of War of Rebellion, Part I., vol. ii., pp. 123, 124 (Fig. 5½). See also Abernethy's Surgical Observations, vol. ii., pp. 68, 69, Am. ed., 1811.

The osteological specimen represented by Fig. 105, is preserved in the Army Medical Museum. It shows the vault of the cranium with the disk in place. The inner table is described as cribriform. The outer table exhibits *osteoporosis*, and is slightly dissolved.

Fig. 105.

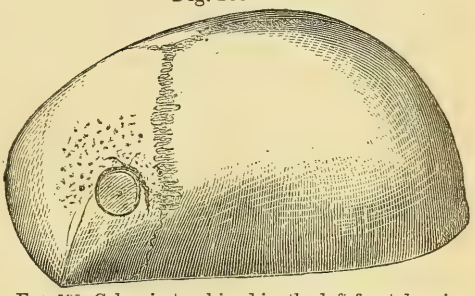


Fig. 105. Calvaria trephined in the left frontal region for gunshot contusion.—*Spec.* 1199, Sect. I., A. M. M.

When contusions of the cranial bones prove fatal, the proximate cause of death is, in most instances, inflammation of the membranes or substance of the brain. Out of 328 cases of this form of injury, which were reported during the war of the Rebellion, 55 patients died; and in 46, or something over four-fifths of the fatal cases, compression of the brain from intracranial abscess, or from various secondary lesions of the encephalon, inflammatory in their nature, produced the fatal result (op. cit., p. 126).

Concerning the "puffy tumor" of Pott, upon which much stress has been laid by some writers, the surgical history of the war shows that this form of pericranial abscess is by no means of frequent occurrence, since it presented itself in but few of the 328 cases of cranial contusion abovementioned.

The presence of Pott's "puffy tumor" of the scalp renders the operative prognosis more favorable than its absence, since it points rather to a limited inflammation, or circumscribed collection of pus beneath the bone or in the arachnoid sac; while its absence is indicative of diffused inflammation or sub-arachnoid effusion, due, probably, to primary lesion—contusion or laceration of the cortex of the brain.]

In all this, it is held that the affection of the bone is the essential element; and such no doubt is the rule. It was, however,

taught by Pott,[1] that the affection of the bone was only secondary to that of its membranes.

In the treatment of these cases, the first question is, whether the inflammation likely to arise from a contusion of the skull-bone can be prevented. Free bloodletting at the onset of the symptoms would, it was at one time thought, prevent further mischief; and by Pott,[2] especially, great success was attributed to this plan of treatment. But, as I shall hereafter explain, these successful cases were, I believe, instances of inflammation beginning, not in the dura mater, but in the visceral layers of the membranes of the brain, and dependent upon what is commonly called concussion. It is no doubt right, as soon as inflammatory symptoms make their appearance after a blow on the head, to have recourse at once to antiphlogistic remedies; but the prospect of the benefit likely to be derived from our treatment must depend upon the cause of the inflammation. In inflammation dependent upon concussion of the brain, antiphlogistic remedies will, in the great majority of cases, be of very great use; but in inflammation beginning in the diploë and spreading to the dura mater, they will be of little or no avail; hence the reason why we so commonly find these cases running their course, notwithstanding bloodletting, mercury, etc.

The increase of symptoms leads to the question of trephining in such cases.

Trephining for matter between the bone and the dura mater appears, in Pott's hands, to have been a most successful operation. Blow on the head—subsequent secession of the pericranium—pain in the head—fever—rigors—application of the trephine—evacuation of matter—cured. Such is the history of the majority—five out of eight—of the cases in which Pott applied the trephine.[3] But no such success has attended the practice of other surgeons. On the one hand, the dura mater has been found, over and over again, perfectly sound in cases where the trephine has been applied for precisely similar symptoms; and, on the other hand, although matter may have been found between the bone and the dura mater, the patient has nevertheless died. I have repeatedly seen the trephine applied under such circumstances, and matter evacuated, but without any permanent benefit. Indeed, the successful issue of a case of trephining for matter between the bone and the dura mater is, I believe, all but unknown to surgeons of our own time.[4]

[The statement just made by Mr. Hewett makes it all the more important in cases of cranial contusion to discern the occurrence of abscess of the diploë, and to evacuate it by trephining the external table as recommended by Abernethy. Hence, when in cases of contusions of the cranial bones, a "puffy tumor" forms, or there is spontaneous secession of the pericranium, or the bone, if denuded, becomes dry and discolored, the surgeon should take into consideration the propriety of trephining the external table with a view to release the imprisoned matter; for, by the timely performance of this operation, he can with certainty every now and then save a patient who otherwise must perish. He should remember, too, that generally the chances of recovery diminish as the operation is postponed. In such cases, he should not hesitate to make an exploratory incision through the scalp down to the bone, when necessary, in order to expose it to view; and if purulent matter is seen oozing from the external table, or from any signs whatever he becomes satisfied that the diploë is suppurating, he should pierce the external table at once with a trephine, discharge the matter, and apply antiseptic dressings.

At the outset, whenever there is reason to believe that the skull is bruised, whether it be from the stroke of bullets, or from blows or kicks or falls on the head, or from any other cause, corporeal and mental rest, as nearly absolute as possible under the circumstances surrounding the patient, should be procured. He should be confined to bed, and all loud sounds, and other cerebral excitants of every kind, should be carefully excluded; in short, everything that is possible should be done to secure quietude of the body as a whole, and quietude of the brain, since rest is Nature's almost universal remedy. The ice-bag also should be applied to the bruised part, for the purpose of keeping down the inflammatory process therein; *i. e.*, in order to prevent its becoming suppurative and necrotic, on the one hand, and to protect the membranes and substance of the brain from its invasion, on the other, for cold used in this way has a wonderful ability to retard and even completely prevent the occurrence of traumatic suppuration. The ice-bag should be constantly kept on the injured part, both day and night, until all danger has been passed; and dry compresses should be interposed between the ice-bag and the scalp, of sufficient thickness to prevent discomfort. The regimen should be antiphlogistic; and any special symptoms should be treated according to their nature. The operative treatment should be that which

[1] Injuries of the Head, 1768, p. 39.

[2] Op. cit., p. 55. [3] Op. cit., pp. 63–107.

[4] [However, sixteen cases of successful trephining for matter between the bone and the dura mater will be referred to in connection with the account of traumatic meningitis further on, all but two of which are quite modern or recent.]

is recommended above; and the operation should never be delayed after the diagnosis is clear or even highly probable.]

Pott was successful because the inflammation in the majority of his cases happened to be strictly limited to the outer surface of the dura mater; and this, Pott thought, was frequently the case; but further experience has proved that this strict limitation of the inflammation is quite exceptional. In every case of contused bone in which I have found inflammation on the outer surface of the dura mater, I have also found inflammation on the free surface of the arachnoid.

With this all but constant diffuse suppuration of the arachnoid which accompanies inflammation of the dura mater in connection with contused bone, there is, then, but very little hope of doing any good by trephining; but as the operation is the only chance left, we must not lay the trephine aside altogether, as some surgeons have done in these cases.

In order, however, that we may avoid the risk of applying the trephine in cases where the dura mater is healthy, we must be especially careful to operate in those cases only where, in addition to fever and rigors, and to the local signs about the bone, there are also well-marked brain-symptoms,—coma, and, better still, hemiplegia. With such a train of symptoms, lymph or pus has invariably been found between the bone and the dura mater in all the cases in which I have seen the skull perforated.

["Now, if the surgeon waits until these symptoms set in, the chances of a successful issue are reduced to a minimum, since they depend upon arachnitis or abscess of the brain. One need not wonder, therefore, that recoveries are unknown under these circumstances, although we must do the writer the justice to say that he advises opening the skull as the only chance left. Mr. Pott did not wait for these fatal symptoms. For him, a slight blow on the head, followed by the formation of pus between the pericranium and bone, pain, restlessness, languor, febrile action, slight rigors, cephalalgia, and quick pulse, were sufficient indications that the dura mater was seriously involved, and that the pus should be let out. I have examined the histories of the cases that have occurred in late wars; their symptoms do not differ from those presented by cases a century back; the only difference, in my opinion, being that Mr. Pott was right in his treatment, and that modern surgeons are very decidedly wrong in delaying operative interference until it is too late to be of any avail."—(S. W. Gross in Am. Journ. Med. Sciences, July, 1873, p. 58.)

Mr. Bryant (Pract. of Surg., p. 183, 2d Am. ed.) says: "When operation is postponed until confirmed brain-symptoms have appeared, there is too much reason to believe that irremediable changes have taken place, such as suppuration within the hemispheres, or arachnitis, which no operation is likely to relieve. Trephining has, however, been of use even in such cases when complicated with epileptiform convulsions; but the surgeon should anticipate this stage of the disease when he can, and interfere before such symptoms appear; headache of a local and persistent character, associated with evident signs of local ostitis or necrosis, is always an indication of the propriety of trephining."]

Now and then, but very rarely, the matter in the cavity of the arachnoid, instead of being diffused, is limited by lymph gluing together the two layers of the serous membrane; and thus is formed a perfectly circumscribed abscess. In such cases, after the skull has been perforated, the dura mater bulges into the trephine-hole; and it is tense, and without any pulsation. Here there is no doubt as to what is to be done. The dura mater must be cut into, in order that the matter be evacuated. It was by thus incising the dura mater that Guthrie[1] saved the life of one of his patients. In Roux's case,[2] after the removal of the bone by the trephine, a large hole was found in the dura mater; this gave free vent to a collection of matter circumscribed within the cavity of the arachnoid, and the patient got well. And Mr. Dumville's recent case affords another striking instance of circumscribed suppuration within the cavity of the arachnoid, and similar in some points to M. Roux's. The girl, Mary Driskell, was admitted into the Manchester Royal Infirmary for a scalp wound and denudation of the frontal bone. The symptoms first made their appearance three weeks after the accident, and led to the supposition that matter had formed between the bone and the dura mater. The trephine was applied; no matter was found on the dura mater, which, however, was whiter and thicker than usual, except at one point of the margin of the trephine-hole, where there was a red spot; this proved to be a small hole in the dura mater, into which the flat end of a probe was passed, whereupon a quantity of most offensive matter spirted out. The symptoms were relieved, and the patient ultimately got well.[3]

Pyæmia in Scalp wounds and Contusions of the Skull.

But of all the complications incident to

[1] Injuries of the Head, p. 127.
[2] Arch. génér. de Méd., 1830, vol. xxiv., p. 268.
[3] Brit. Med. Journ., 1858, vol. ii., p. 743.

the slighter forms of injury of the head, none is so fatal as purulent infection, which may arise out of a simple wound of the scalp, or, as is much more frequently the case, be connected with contusion of the skull, followed by inflammation and suppuration of the diploë, in which some of the large and numerous venous canals of the bone have become implicated.

In purulent infection arising out of either of these causes, the brain and its membranes may remain perfectly healthy. With contusion of bone, however, it much more commonly happens that purulent infection is associated with intracranial suppuration.

The frequent association of purulent infection with slight injuries of the head must be kept constantly in view; for its symptoms sometimes resemble very closely those of intracranial suppuration; so much so that, unless on our guard, we may be misled, and especially in the early stages, when there are as yet no signs of mischief in other parts of the body. And the diagnosis will be still more difficult, if not altogether impossible, in those cases where there is matter between the bone and the dura mater, as well as purulent infection.

It is a fortunate circumstance that purulent infection, or pyæmia, is *per se* not prone to attack this class of injuries. In 328 cases of contusions of the cranial bones from gunshot, which occurred during our civil war, but one example of pyæmia was reported. On this point, see Otis, op. cit., p. 122.

In 331 cases of "uncomplicated contusions or lacerations of the scalp," caused by miscellaneous injuries not gunshot, such as blows, kicks, falls, etc., that were reported during our civil war, pyæmia did not occur in any instance. (Op. cit., pp. 61–64.)

In 7739 cases of wounds of the scalp from gunshot that were returned during the war, "the reports specify five cases in which pyæmia supervened." (Op. cit., p. 84.)

Thus we have, altogether, 8398 cases of injury of the head, without fracture, in which pyæmia was reported in but six instances. Whenever, then, the purulent infection is found to be frequently associated with this class of injuries, it is most likely due to some local cause, such as foul air, "hospitalism," etc., from the destructive powers of which the patients can and should be freed promptly by removal, if the local cause itself can not be removed.

It is, however, worth remembering in this connection, that traumatic pyæmia, in a very large majority of instances, results from injury of bone. (Sixth Rep. of Med. Officer to Privy Council, p. 61).

For a long time the liver was thought to be the spot in which secondary abscesses occurred in connection with an injury of the head; but further experience has proved that matter may, in such cases, form in any and in every part of the body, and that the lungs are, of all parts, the most frequently thus affected. Out of eighteen cases, in all of which the purulent infection occurred either after a wound of the scalp or a contusion of the bone, I found the lungs studded with secondary abscesses in thirteen cases, and the liver in three; and out of these three the liver alone was affected in one case only, and in the other two the lungs were affected as well as the liver. In purulent infection, the serous membranes are also frequently the seat of secondary inflammations; and here we shall also find that the serous membranes of the chest are much more frequently affected than those of the belly. Thus, out of these eighteen cases, the pleura was extensively inflamed in no less than twelve cases, and the peritonæum in one case only. In some of these cases the inflammation was confined to the serous membrane; but in most of them the pleura and the lung were both affected. In the limbs, the joints are not unfrequently filled with matter, and large collections of pus occur at different points in the cellular tissue. Even the skin, as is now well known,[1] may become affected in purulent infection. Now and then, but very rarely, the skin is studded with small deposits of matter, looking exactly like the pustules in a bad case of small-pox. Of this I have seen only two or three instances. In other cases, the skin is covered with sundry patches of a purple hue, resembling the circumscribed patches of congestion commonly seen about the lung in an early stage of the disease; and in other cases, again, a large portion of the skin is suddenly stricken with mortification, which proceeds very rapidly. Of this I have seen several instances.

A careful examination of the venous system of the head shows, in some cases, the veins of the scalp filled with pus [or puriform matter]; in other cases, pus [or puriform matter] is found in large quantities in the veins of the diploë; so much so that, in trephining for matter between the bone and the dura mater, I have several times seen pus [or puriform matter] streaming out of the large venous canals of the diploë; and within the skull, the veins on the surface of the hemispheres are sometimes loaded with pus [or puriform matter] and so too, and much more commonly, is the superior longitudinal sinus.

[1] Henry Lee, Inflammation of the Veins, etc., 1850, p. 53.

[Concerning pyæmia, see Bryant (Pract. of Surg., 57–58, 2d Am. ed.).

The writer is convinced from his own experience that the relation between thrombosis, with or without phlebitis, and pyæmia, is not that of cause and effect. 1st. Because he has seen a number of fatal cases of pyæmia with secondary abscesses in which thrombosis was not present; and 2d, because he has often examined fatal cases of pyæmia in which the blood-clots in the affected veins were all quite fresh-looking, and, consequently, the thrombosis was very recent, and had obviously occurred subsequently to the formation of the secondary abscesses. The writer concludes from his observations and reflections: 1. That pyæmia is a zymotic disease of septic character. 2. That its exciting causes are bad hygienic conditions, such as hospital air and overcrowding, effluvia from filth, neglected wounds, and putrescent suppuration. 3. That its efficient cause is a subtle poison, or contagium, of septic origin, which enters the circulation by absorption, and thus becomes disseminated throughout the organism. 4. That this poison, when diffused through the system in the circulating blood, exhibits a strong affinity or preference for certain organs and tissues, in which it kindles inflammatory action, and thus produces the so-called metastatic or secondary abscesses, and the so-called pyæmic or secondary serous inflammations. Thus the pyæmic poison, in the affinity which it manifests for certain organs and tissues in preference to others, is analogous in its operation to the poison of small-pox, typhoid fever, glanders, plague, and infectious diseases in general.]

Treatment of Pyæmia.

In purulent infection, surgery can do nothing unless the pus happens to be altogether effused into parts which are accessible, such as the joints, or the cellular tissue. Of late years, however, M. Chassaignac has proposed that we should once more resort to the trephine as a preventive; that we should cut out the contused piece of bone in which suppuration is likely to take place, and thus remove the starting-point of the disease. But the objections to this proposition are so obvious, that few surgeons will, I think, venture to put it into practice.

And, medically, our only hope is in keeping up the general strength by all possible means, bearing in mind that cases do now and then occur in which recovery takes place, notwithstanding clearly marked symptoms of purulent infection—cases in which inflammation of the lung has existed, and in which large collections of matter have burst, and been brought up.

[An unlimited supply of fresh air, simple nutritious food, and, where a wound or suppuration exists, the most thorough *cleanliness*, are the main points of practice to be attended to in the treatment of every case of traumatic fever or pyæmia. Compared with these, all other means are of secondary importance (Bryant).

There is one internal remedy which I have often found decidedly beneficial, namely, the sulphate of quinia. It does most good when administered in large doses, for example, ten grains every four or six hours. Preparations of iron, more especially the tincture of the sesquichloride, have also been found useful. For scorbutic cases the tartrate of iron and potassa may be preferable. I have seen the tincture of the sesquichloride administered with benefit in doses of twenty drops every four hours. The exhibition of anodynes is often required to alleviate pain, and quiet restlessness.]

In dealing with purulent infection—in dealing, too, with erysipelatous and diffuse cellular inflammation of the scalp—we must also bear in mind, that disease of the kidneys may possibly be at the bottom of the evil. Patients affected with Bright's disease are especially liable to extensive inflammations of the cellular tissue, just as well as of the serous membranes. And in this condition of the kidneys one not unfrequently sees diffuse cellular inflammation beginning around a slight wound of the scalp, and rapidly spreading over the head and face, and down the neck into the mediastina. In such cases, too, one or more of the serous membranes may also be filled with sero-purulent fluid.

Extravasations of Blood.

Blood may be extravasated in the soft parts external to the bone; in the bone itself; between the bone and the dura mater; within the arachnoid; in the pia mater; in the structure of the brain, or in its ventricles.

In the parts external to the bones.—The extravasation may take place between the skin and the occipito-frontalis muscle, in the loose cellular tissue under this muscle, or beneath the periosteum. In either of these situations the extravasation may be infiltrated into the tissues, or inclosed in a cavity more or less well circumscribed.

Infiltrated.—In the very dense cellular tissue between the skin and the occipito-frontalis muscle, the blood presents itself as a hard unyielding lump; but beneath the muscle it spreads through the meshes of the cellular tissue, and gives rise to a crackling sensation.

Inclosed in a cavity.—The extravasation may form either a prominent tumor, with

a soft centre and a hard base, or a diffused swelling, with boundaries gradually lost in the surrounding tissues. Diffused swellings of this kind occur as well under the pericranium as in the loose cellular tissue above this membrane; and in either case the collection of blood may be such as to cover over the whole surface of the calvaria.

The fluid in these collections varies very much at different periods; it may be blood, arterial or venous, in a more or less fluid state; or a thick viscid fluid, of a dark, bistre color; or bloody serum with clots, or serum alone. And the cavity containing the fluid, formed at first by the surrounding tissues only, is subsequently lined by a perfectly-formed membrane possessing all the attributes of an original serous tissue, and to this is sometimes added a thick deposit of fibrin disposed in layers such as are found in an aneurism.

The diagnosis of extravasations of blood external to the bone is, for the most part, easy; but the extravasation with a hard ridge round its base and a soft centre may lead to some difficulty. It has been mistaken for a fracture with depression, and that by some of the most practical surgeons; and all the more readily may such an error occur when the swelling, in connection with a lacerated artery, pulsates.

In the treatment of these external extravasations of blood there is generally but little to be done; in due course of time the blood is absorbed. But it occasionally happens that the collection persists, and even increases in size, and under such circumstances it may be necessary to evacuate the fluid. This must be done by a small puncture, after which compression is to be established over the whole surface of the swelling. In large collections, such puncturings may have to be repeated several times; and in an encysted collection of large size, should the fluid be of a serous character, and recur again and again, an iodine injection might be thrown into the pouch. And when suppuration occurs, the pouch must here, as everywhere else, be at once freely laid open.

Extravasations of blood *in the diploë*, and the consequences to which they may give rise, have already been dwelt upon in the previous section.

Extravasations of blood *between the bone and dura mater* may proceed from the small vessels passing from the one to the other, or from some of the large vessels lodged in the grooves on the inner surface of the skull. The former extravasations, generally speaking, are of small size; but the latter may be very extensive, widely separating the membrane from the bone over the greater part of one side of the skull. Of the large extravasations, the most frequent by far is that from the middle meningeal artery. Out of thirty-one cases of fracture of the skull, accompanied by extensive extravasation, the blood had proceeded from the middle meningeal artery or its branches in twenty-seven cases. Occasionally the extravasation proceeds from one of the large venous sinuses, and of these the lateral is more commonly lacerated than any other sinus. One of the most extensive extravasations of blood between the bone and the dura mater which I have seen, proceeded from a rupture of the lateral sinus, just as it turns under the petrous portion of the temporal bone.

[Guthrie (Commentaries on Surgery, p. 351, Am. ed.) justly remarks: "A wound of the longitudinal or lateral sinuses, allowing a free discharge of the blood poured out, is of comparatively little consequence. It is, on the contrary, a very fatal injury when the blood is permitted to accumulate."]

The spot usually referred to in extravasation of blood from the middle meningeal artery is the anterior inferior angle of the parietal bone; but extensive extravasations may occur from this vessel or some of its branches over pretty nearly the whole of the lateral surface of the skull. In fractures involving the middle fossa, the most common of all the fractures of the base of the skull, this vessel may be torn across in any part of its course between the foramen spinosum and the anterior inferior angle of the parietal. And in the middle fossa of the skull, it frequently happens that the middle meningeal artery divides itself into two large branches of equal size, one proceeding to the anterior inferior angle of the parietal, and the other passing much more posteriorly, which send large ramifications over the whole of the parietal and the corresponding parts of the frontal and occipital. A fracture running across any of these large branches may give rise to an extensive extravasation of blood.

A collection of blood between the bone and dura mater differs widely from extravasations of blood in other parts of the cranial region. It always presents itself in the shape of a hard granular mass, breaking down with great difficulty, even under heavy pressure, and adhering most firmly to the parts between which it is lying; separating, more or less widely, the dura mater from the bone; and pressing upon the brain itself, sometimes to such an extent as to produce a large cup-like cavity on its surface.

The changes likely to take place in such an extravasation, should the patient live, are very few. It has been doubted whether blood between the bone and the dura mater could be absorbed; but in one instance,

where the patient lived for a few weeks after the accident, I found thus situated a small hard clot, which had already lost the greater part of its coloring matter, and was undergoing the process of absorption. As for these collections becoming encysted, of this I know no well-authenticated case; neither have I ever seen, even after several days, anything approaching to the formation of a cyst.

The symptoms dependent upon an extravasation of blood between the bone and the dura mater vary very much. In small extravasations the symptoms may be but slightly marked; and in a slow outpouring of blood, the brain may have time to accommodate itself to the pressure. In well-marked compression, however, the patient is generally perfectly insensible: the breathing is slow and labored, oftentimes stertorous, and sometimes accompanied by a peculiar whiff at the corner of the mouth; the pulse, too, is slow and labored; the pupils may be either contracted or dilated, and the eye fixed and insensible to light; there is paralysis, more or less complete, of one side, with retention of urine and involuntary discharge of fæces.

It unfortunately happens, however, that the symptoms of compression bear at times a very close resemblance to the symptoms of concussion and of contusion of the brain, so much so in some cases that it may become a difficult matter to decide as to the exact nature of the injury. But, however alike the symptoms of compression and of concussion may at times be, there is this marked difference between the two states,—in concussion, the effects are instantaneous; and in compression from extravasated blood, some little, it may be a very short, time elapses before the symptoms manifest themselves; in the former, also, the symptoms gradually pass off, but in the latter they become more and more marked.

In the year 1839, a man was struck with a spade just over the anterior-inferior angle of the right parietal; and when he came to St. George's Hospital a few minutes afterwards, a compound fracture, with depression of a small piece of the skull, was detected, but there was no cerebral symptom whatsoever. Shortly afterwards, however, the patient became heavy and stupid; and coma was gradually supervening, when Mr. Keate arrived, and at once proceeded to remove the depressed bone, whereupon a jet of blood spirted out from a large branch of the middle meningeal artery, and all the symptoms of compression were immediately relieved.

In this case there was no doubt as to the symptoms being wholly dependent upon the extravasation of blood which was going on under the bone; there was no injury of the brain itself, and the interval between the blow and the symptoms was clearly marked. But had concussion of the brain existed, the outpouring of blood might have taken place when the patient was insensible, and then we should have lost our most valuable means of diagnosis, the "interval of time." Again, in civil hospitals, nearly all large extravasations of blood between the bone and the dura mater coexist with contusion and laceration of the brain-substance. The post-mortem records of St. George's Hospital show that within the last few years there have been twenty-five cases of large extravasations of blood between the bone and the dura mater, in all of which the brain was more or less extensively lacerated.

Injuries of such a compound nature easily explain the difficulties as to diagnosis, and the reason why the trephine is so seldom applied nowadays for extravasated blood; and why also, when resorted to, the operation so seldom succeeds.

But cases now and then occur in which there is no doubt as to the propriety of applying the trephine, and in which its application is followed by the most signal success. Of this Mr. Keate's case above-mentioned affords a striking illustration; and in the year 1842 there was another case of the same kind, at St. George's Hospital, under the care of Mr. Tatum, and in which the operation was equally successful.

In other cases, the history of an extravasation of blood may be perfectly clear, but there may be no local sign as to the seat of the injury, and perhaps even nothing to guide us as to which part of the head was struck. Under such circumstances, operative interference is out of the question, unless paralysis be present.

[In proof that the statement in the text is far too sweeping, see Am. Jour. of Med. Sciences, January, 1879, p. 178.]

But should paralysis exist on one side, we may infer that the extravasation of blood is, at any rate, on the opposite side; and then an incision over the lower part of the corresponding parietal is warranted; for a fissure of the skull may thus be laid bare, the trephine applied, and the patient saved.

[Many successful cases of trephining for compression of the brain from blood extravasated between the skull and the dura mater are on record. Dr. Wilks (Guy's Hospital Reports, 1866, p. 194) relates a typical example; Quesnay (Select. Mem. Royal Acad. Surg. of France, Syd. Soc. translation) relates four strongly marked cases. They are Obs. 7, p. 8; Obs. 10, p. 12; Obs. 11, p. 14; and Obs. 20, p. 21. In all of them recovery was hopeless without the operation. Abernethy (Injuries of the Head, pp. 24–27, London, 1797) successfully trephined a boy, aged 14, hurt by

falling on his head from a scaffold and brought to the hospital in apparently a dying state. The instrument was applied three times in order to uncover the clot. Hennen (Military Surg., pp. 261–265, Am. ed.) records a very interesting case which belongs to the same category. Six applications of the trephine, only one of which embraced a perfect circle, were necessary, and an enormous clot was removed. The man was saved. Guthrie (Commentaries on Surg., p. 349, Am. ed.) also reports a case in point. Five cases of cerebral compression complicating gunshot fractures of the skull are related in the Med and Surg. Hist. of the War of the Rebellion, first Surgical Volume, pp. 279, 281, 286, 289, in which the trephine was applied, the coagulated blood was removed, and recovery followed. See also Sir Benjamin Brodie (Med.-Chir. Trans., vol. xiv., p. 385).

But, in cases of trephining for cerebral compression where the middle meningeal artery is lacerated, it sometimes happens that the artery continues to bleed after the clot has been taken out. Now, what is to be done in such cases? 1. We should endeavor to close the open mouth of the vessel by torsion. 2. Should torsion be impracticable, and the outflow of blood from the artery continue, the trephine should be applied over the course of the artery, a disk of bone removed, and a ligature placed round the vessel itself.

In this connection it may be of some interest to state that during our civil war the common carotid artery was tied for hæmorrhage from the middle meningeal, in two instances of shell-fracture of the skull, with permanent arrest of the bleeding. (Op. cit., pp. 255, 256, 314.) When we are certain that the hæmorrhage is restricted to the middle meningeal artery, the external carotid, a branch of which the middle meningeal is, should be tied instead of the common carotid, for the ligation of the former is much less likely to be followed by bad consequences, *per se*, than the ligation of the latter, while it is quite as likely to control the bleeding.]

In the cavity of the arachnoid, traumatic extravasations of blood occur much more frequently than in any other part within the skull. Such extravasations are, indeed, very common, and much more so than is usually supposed. Blood is found in the cavity of the arachnoid in the great majority of severe injuries of the head; and I have frequently found it also in cases where the injury has been a trifling one, and that without any apparent lesion either about the brain or its membranes.

In the majority of instances the blood corresponds to the cerebrum, rarely to the cerebellum, and still more rarely to the medulla oblongata.

Blood extravasated within the cavity of the arachnoid undergoes, in the course of time, various changes, which it is important to notice.

In the earlier stages, the blood, when coagulated, is flattened and moulded, membrane-like, upon the parts between which it lies. In this shape I have frequently found large quantities of blood spread over and capping both hemispheres of the brain. After a time the coloring-matter of the blood disappears, more or less; and thus are formed the membranes, of different hues, which are found within the arachnoid after an injury of the head. In slight extravasations, all that may be found after a few days is a mere film, so delicate and so slightly tinged as easily to escape notice.

In the great majority of cases, the false membrane is firmly attached to the parietal arachnoid (FIG. 106); its free surface, perfectly smooth and polished, presents the appearance of a serous tissue; and its structure is throughout plentifully supplied with bloodvessels, which may be readily seen with the naked eye. I have met with all these characters, well marked, three-and-twenty days after an injury.

These blood-membranes, at first soft and pulpy, may subsequently become leathery, fibrous, or even cartilaginous; and, under such circumstances, they have been referred to and described as diseases of a very different character, and especially chronic inflammation.

Extravasations of blood into the cavity of the arachnoid not unfrequently give rise to appearances of a deceptive character.

The blood, glued to the parietal arachnoid, and covered over by a thin, polished, serous-like membrane, looks exactly as if the extravasation had taken place between the dura mater and its arachnoid, and widely separated these membranes from each other. But the true nature of these cases has of late years, and especially by the French pathologists, been clearly made out.[1]

[Prof. Huguenin (Ziemssen's Cyclopædia, vol. xii., pp. 389–395) gives a description of the anatomical appearances pertaining to hæmatoma of the dura mater, drawn from his own personal observations, which strongly supports Mr. Hewett's views.]

Instead of forming simple layers of membrane, the blood, if the extravasation is a large one, may in the course of time give rise to the formation of a large perfectly-closed bag, in which are contained the more fluid parts (FIGS. 107, 108). Such blood-cysts may contract more or less extensive adhesions with both layers of the arachnoid; but they are, for the most part, glued to the parietal arachnoid only; and in some

[1] Prescott Hewett, On the Ext. of Blood into the Cavity of the Arach., Med.-Chir. Trans., vol. xxviii., p. 45.

rare cases, they have been found lying perfectly loose in the cavity of the arachnoid. In M. Leriche's case,[1] the blood-cyst lying loose in the cavity of the arachnoid was an inch and a half in width; and it covered over the greater part of the upper part of the upper surface of the left hemisphere, where it had imbedded itself. In Dr. Quain's case,[2] the cyst fell out of the cavity of the arachnoid when the dura mater was incised; and measuring in length seven inches and a half, and in width one inch and a half, at its broadest part, this cyst had formed a corresponding depression on the upper surface of the cerebral hemisphere. The preparation is now in the Museum of St. George's Hospital.

Fig. 106.

FIG. 106. Layer of coagulated blood attached to the parietal arachnoid, from which it has been separated at the upper part.

When glued, as they commonly are, to the parietal arachnoid, these blood-cysts are thoroughly supplied with bloodvessels; and thus organized, these cysts possess all the physiological characters of an original serous membrane. They secrete; they absorb; they have been found filled with clots of fibrin and blood-tinged serum; sometimes they contain serum alone, of various colors; and oftentimes in the cavity of the same cyst are found clots of blood of various colors, some recently effused, and others of long standing.

When the cyst is a large one, it presses upon the corresponding part of the brain, the convolutions of which become flattened, or slightly depressed, presenting a cup-like surface, and the corresponding ventricle is contracted. The pressure of the cyst, in long-standing cases, diminishes the thickness of the bones; and, in some cases, when formed in early childhood, such cysts have been known to lead to bulging of the bones outwards.[3]

[1] Bull. de la Soc. Anat. de Paris, t. x., p. 55.
[2] Trans. Path. Soc. Lond., vol. vi., p. 8.
[3] Lancet, 1846, vol. i., p. 416.

There are no symptoms which will enable us clearly to diagnose an extravasation of blood into the cavity of the arachnoid.

If slight, such an extravasation may be followed by no symptoms whatsoever; and, even in larger quantities, when spread out in membranous layers, the blood may produce no very decided symptoms of compression; and most frequently, connected as these extravasations are, in the great majority of cases, with severe injury of the cerebral substance itself, the symptoms of one lesion are mixed up with, or totally masked by, those of a very different nature.

But should symptoms of compression follow a traumatic extravasation of blood in the cavity of the arachnoid, they will be the same as those of a collection of blood upon the outer surface of the dura mater; and a surgeon may thus be led to apply the trephine under the supposition that the blood is in this situation.

And now, supposing the trephine to have been thus applied, and no blood found between the bone and the dura mater, still the blood in the arachnoid may chance to lie immediately under the spot, and the dura mater, of a blue color, may bulge into the trephine-hole. Under such circumstances, blood in the cavity of the arachnoid has several times been let out, and the patient saved. When, however, there are no indications of the blood in the arachnoid being under the trephine-hole, there is nothing to justify the surgeon in proceeding further.

[Numerous cases are on record wherein this operation was successfully performed. J. L. Petit's (Œuvres Complétes, p. 353, Paris, 1844), is probably the earliest.

Sir Benjamin Brodie (Med.-Chir. Trans., vol. xiv., pp. 388–391) cites two most interesting examples.

Equally happy results have been obtained by trephining the skull and incising

the dura mater in similar cases by Morand (Opuscules de Chirurgie, P. I., p. 171, Paris, 1768), and by Hecker, Bremond, and Ricker (Bruns, Handbuch der Prak-

Fig. 107.

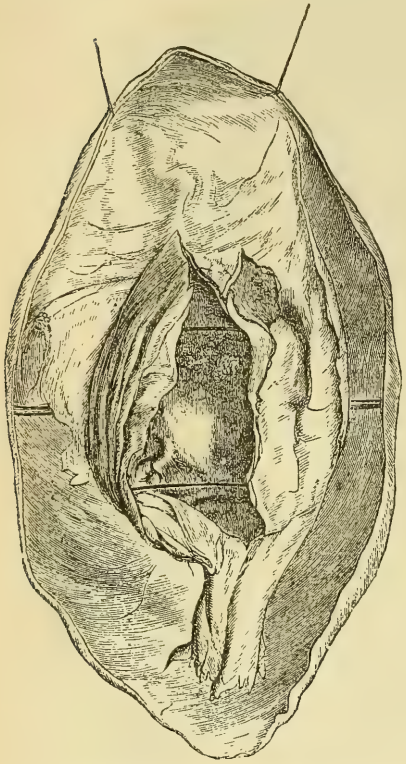


Fig. 107. Large blood-cyst attached to the parietal arachnoid; the cyst laid open to show its cavity.

tischen Chirurgie, Abth. I., pp. 931–935), after blows and falls upon the head.

Two cases of this kind are reported in the Med. and Surg. History of the War of the Rebellion, First Surg. vol., pp. 282, 283. See also, Macewen (Brit. Med. Journ., Dec. 27, 1879, p. 122).]

Traumatic extravasations of blood in the cavity of the arachnoid sometimes give rise to a permanent affection of the brain.

In Dr. Quain's case above cited, in which a large blood-cyst was found loose in the cavity of the arachnoid, the injury was followed by constant pain in the head, great irritability of temper, despondency, and subsequently by fits, which recurred from time to time. In Mr. Fisher's case, published by Mr. Hancock,[1] the patient, a young gentleman, became insane after a

[1] Lancet, 1846, vol. i., p. 416.

violent blow on the head from a cricket bat or ball, and in this state he remained, with occasional lucid intervals, for fifteen years, and all that was found after death

Fig. 108.

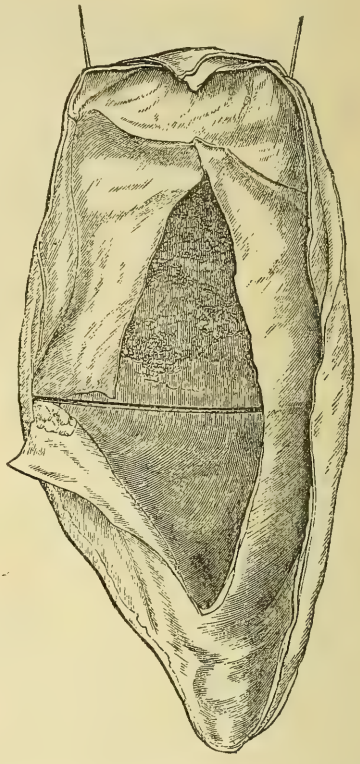


Fig. 108. Another large blood-cyst also laid open, and dissected off from the parietal arachnoid the greater part of its extent.

was an enormous encysted collection of blood in the cavity of the arachnoid. And in Foville's[1] and Blandin's[2] cases, both of old soldiers in whom severe injuries of the head were followed by insanity, large collections of blood were years afterwards found encysted in the cavity of the arachnoid.

Traumatic extravasations of blood *in the pia mater* differ in many respects from those in the cavity of the arachnoid. They certainly occur less frequently, and they very rarely exist without some laceration of the brain-substance. Beneath the arachnoid, an extravasation of blood spreads into parts far away from the original seat of the injury, and the whole cerebellum and spinal marrow may thus be covered with blood proceeding from a laceration of the

[1] Dict. de Méd. et de Chir. Prat., t. xi., p. 407.
[2] Anat. des Régions, 2me éd., 1834, p. 36.

cerebrum only. In the pia mater, too, an extravasation of blood never, as far as I am aware, gives rise to encysted collections such as those which have been described in the cavity of the arachnoid.

It was at one time thought that these widespread extravasations of blood in the pia mater were apt to produce more urgent symptoms than those collections of blood in one mass which gives rise to a less general pressure; but further experience has not confirmed this opinion, and it is now admitted that there are no symptoms by which an extravasation of blood in the pia mater can be recognized. Neither is there any possibility of these extravasations being let out, even supposing the dura mater to have been laid open. The constant infiltration of the blood in the pia mater precludes any such fortunate result. [Two marked instances of this kind have been observed by me.]

Injuries of the head sometimes give rise to large extravasations of blood *in the structure of the brain*, and occasionally, too, the ventricles are found filled with blood after injuries of this kind. But in dealing with such cases great caution is necessary, in order to avoid, if possible, mixing up cases of apoplexy with those of traumatic effusions. An accident coexisting with an extravasation of blood in the cerebral substance does not necessarily imply cause and effect; the previous condition of the brain or the outpouring of blood from diseased vessels, may, in fact, have been the cause of the accident. There is no doubt that many a case reported as one of traumatic effusion of blood in the brain was simply a case of apoplexy.

Minute extravasations of blood in the brain will find their appropriate place in the subject of CONTUSION OF THE BRAIN.

Collections of blood in the brain, or in its ventricles, the result of an accident, may run through the numerous and well-known changes of a simple apoplectic effusion. But such changes seldom, however, take place in traumatic extravasations, which are generally rapidly fatal, being, as they are for the most part, associated with other severe lesions of the cranial contents.

[An interesting example of traumatic blood-clot undergoing absorption and fatty metamorphosis in the brain-substance, several months after the hurt occurred, is given in the Med. and Surg. Hist. of the Crimean War, vol. ii., pp. 287, 288.

The annexed woodcut (FIG. 109) furnishes an excellent illustration of traumatic extravasation of blood in the parenchyma of the brain.

The history of the case is in the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 42.]

The symptoms of a traumatic extravasation of blood into the brain are the same as those of an apoplectic effusion. And the treatment, too, must be precisely similar. It, as well as all other treatment of intracranial extravasations, not admitting of operative interference, must be purely medical.

[Fig. 109.

FIG. 109. Part of the left hemisphere of the cerebrum, containing a large ventricular clot. Spec. 505, Sect. I., A. M. M.]

[INCISED WOUNDS OR FRACTURES OF THE SKULL.

This form of injury occurs not unfrequently in military life from sword-cuts, and in civil life from blows with cleavers, axes, and other sharp-edged implements of industry; and obviously requires some notice in this place. See cases by Guthrie (Commentaries on Surgery, pp. 361, 362, Am. ed.), Macleod (Notes, etc., p. 165, Am. ed.), and by the writer (Am. Jour. Med. Sciences, January, 1880, pp. 121, 122).

Fig. 110.

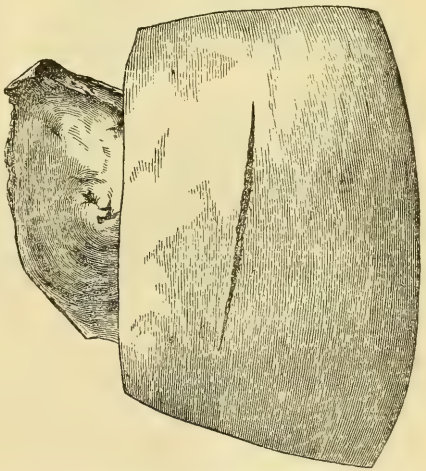


FIG. 110. Sabre-cut of the right parietal. Spec. 4206, Sect. I., A. M. M.

Forty-nine cases were reported during the war of the Rebellion (Med. and Surg. Hist., vol. ii., p. 16).

Fig. 111.

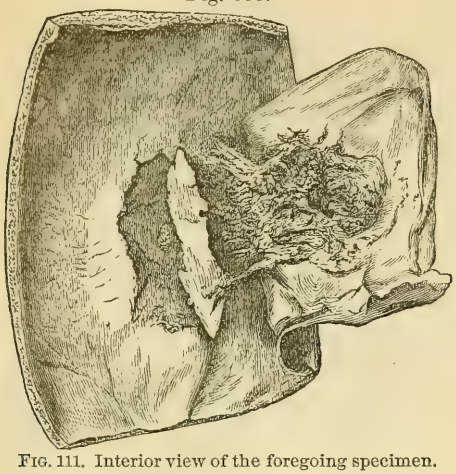


FIG. 111. Interior view of the foregoing specimen.

For history of FIG. 110 and FIG. 111, see Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 18.

For history of this case (FIG. 112), see Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 19. The figure is also taken from that work.

Fig. 112.

FIG. 112. Sabre-cuts on the back of the skull. Spec. 3307, Sec. I., A. M. M.

The statistics collected in our war corroborate the observation of Hennen and others, that sabre-wounds on the top of the head are not by any means so dangerous as those on the sides (p. 23).]

FRACTURES OF THE SKULL.

These fractures may, for practical purposes, be conveniently divided into fractures of the vault, and fractures of the base, of the skull [a third and large division including those of the vault and base. They may also be *simple* or *compound*, *comminuted*, *depressed* or *undepressed*, *complicated*, etc.]

Fractures of the vault.—In the vault, most of the fractures are direct; the bone gives way at the spot which was struck, and the result may be simply a fissure, or the bone may be broken into fragments.

The fissure is most frequently not limited to the seat of the injury; sometimes it spreads through various bones, and oftentimes reaches from the vault into the base.

The comminuted fracture is much less apt to spread; produced by a more or less concentrated blow, such a fracture is for the most part limited to the seat of the injury.

The comminuted fracture and the fissure may coexist, and this especially in cases of a heavy blow acting on a large surface.

Fractures of the vault may be limited to the outer or to the inner surface of the skull; but such fractures by far most commonly extend through the whole thickness of the bone. And the broken bone may either retain its proper level, or be driven outwards or inwards.

The displacement outwards very rarely happens; there are, however, two specimens of it in the Museum of St. George's

Fig. 113.

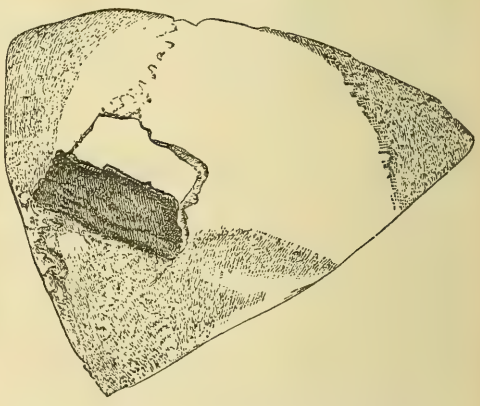


FIG. 113. Fracture of the skull, with displacement outwards. From St. George's Hospital Museum.

Hospital. In both specimens, a piece involving the whole thickness of the bone, having been detached on three sides, is bent outwards, and thus raised two or three lines above the level of the skull: the fragment is, however, immovable, as it is still connected at one side to the surrounding bone, the external table of which is, at this part, only partially fractured; the appearances may, in fact, be said to resemble the

lid of a box partially open. In one instance the injury was produced by a chisel falling from a great height on to the head; and in the other, the patient, in a fall from a great height, struck his head upon some iron railings, one of which penetrated the skull.

The displacement inwards is of very common occurrence. The external table alone may be driven down; and this may happen in any part of the vault, but especially in the region of the frontal sinuses, where the depression may be very extensive, without any injury of the inner table. The inner table alone may be broken and depressed,

Fig. 114.

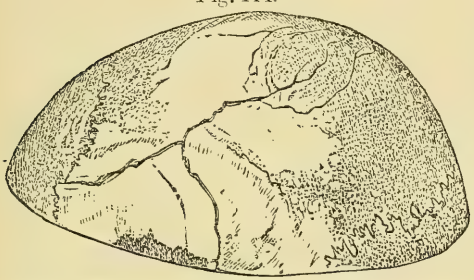


FIG. 114. Fracture of skull, with depression of inner table. *Outer surface.*

without a trace of injury about the outer parts of the bone. Cases such as these are, it is true, very rarely met with; but extensive splintering and depression of the inner table not unfrequently exist, with some slight injury of the outer table. In the Museum of St. George's Hospital there is a skull-cap (FIGS. 114, 115) with a comminuted fracture of the inner table with extensive depression, and in the outer table corresponding to this there are merely some slight cracks. And in another preparation in the Museum of the St. George's Hospital, with splintering and depression of the inner plate alone, there is a simple clean cut of an inch long, through the outer layers of the bone: the boy had fallen out of a cart, and no doubt the bone was cut by some sharp piece of stone lying on the road. In his remarks upon this important subject, it was to sabre-cuts that Mr. Guthrie[1] referred especially; but such appearances about fractures of the skull are by no means uncommon in civil hospitals. A smart blow inflicted on the skull by a more or less pointed instrument—a nail, the corner of a brick, a piece of flint, the angle of a slate—may produce such a fracture. M. Denonvilliers[2] presented to the Société de Chirurgie de Paris a specimen of this kind, in which the injury had been produced by a slate falling on the head. A case is also described by Mr. Benjamin Phillipps,[3] in which a large fragment about two inches and a half long was found completely detached from the inner table, and sticking in the dura mater; in the outer table was a clean cut made by a flat-iron or shovel. In Samuel Cooper's[4] case the injury was caused by a nail projecting from a door which had fallen upon the patient.

Fractures with depression involving the whole thickness of bone present some varieties deserving of notice. There may be, as in a specimen in the Museum of St. George's Hospital, a single line of fracture extending some distance, with an extensive overriding of one side of the fracture.

Fig. 115.

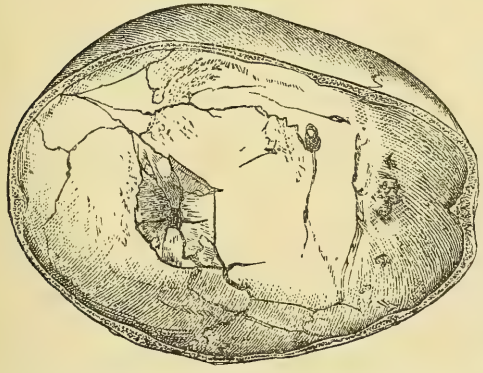


FIG. 115. Fracture of skull, with depression of inner table. *Inner surface.*

Fig. 116.

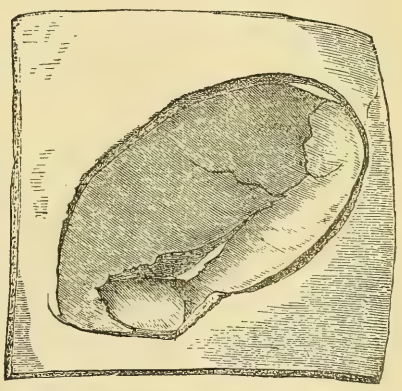


FIG. 116. Depressed fracture of skull, in an oval-shaped piece, driven down and split.

A very common form of fracture with depression is that in which an oval piece of

[1] Injuries of Head, p. 86.
[2] Compend. de Chir. Prat., t. ii., p. 578.
[3] Med. Gaz., vol. xxxiii., 1844, p. 129.
[4] Erichsen, Surgery, 2d. ed., p. 280.

bone is not only driven down, but split longitudinally in two fragments which slant towards each other, the depression being much greater at the centre than at the circumference. With such appearances on the outer surface, the fracture of the inner plate is much more extensive and much more irregular. A specimen in the Museum of St. George's Hospital (FIG. 116) affords a strongly marked instance of this form of fracture, of which I have seen several cases. Such a fracture is commonly produced by some heavy body with a sharp margin applied with great force—a quoit or a horseshoe. But perhaps the most ordinary form of fracture with depression is that in which several fragments, more or less of a triangular shape, have their points extensively driven down and firmly wedged into each other, whilst their bases still remained on a level with the surrounding bone. Taken as a whole, the broken portion is here, too, almost always of an oval shape, and cracks and fissures involving only the outer table are frequently found disposed around the depressed piece. And here too, whatever be the extent of the injury in the outer part, that on the inner side is much more extensive still. And so it is in all ordinary cases of fracture with depression.

The more extensive splintering and depression of the inner table of the skull is usually attributed to its greater density and consequent brittleness; but there is no doubt that the direction in which the force acts tends in some measure to produce these effects. Of this Mr. Erichsen[1] mentions a well-marked example. A man fired a pistol into his mouth, and the ball in passing out of the skull first struck the inner and then the outer plate of the vault. The result was, that the outer plate was much more extensively splintered than the inner one.

As to traumatic depression of the skull without a fracture, of this we have no well-authenticated specimen in the adult. And until such a preparation be brought forward, the existence of this form of injury in the adult ought not to be admitted. In young children with very pliant bones, it is just possible that such an accident might occur; but even here, in a well-marked depression, some of the bony fibres must have given way.

A wound of the integument leading down to the bone may accompany every variety of fracture of the vault. And in these compound fractures, the injury of the bone is very much more frequently strictly limited to the seat of the blow than it is in cases of simple fracture. Out of twenty cases of compound fracture of the vault, the injury of the bones was thus strictly limited to the seat of the blow in eight cases; in six of which the injury was produced by heavy blows, falls, or blunt instruments, and in two by sharp instruments. But out of fifty-six cases of simple fracture this strict limitation existed only in one single instance, and in this case the patient, having fallen off his coach-box, had struck his head against the ground.

Are there any signs by which we can in all cases recognize the existence of a fracture of the vault? No. Fissures involving the whole thickness of the vault of the skull constantly exist without ever having been suspected during life; and even an extensive and comminuted fracture with great depression of the fragments may, and often does, escape notice, when the broken bone lies hidden under the temporal muscle or under a large extravasation of blood. And, on the other hand, an extravasation of blood may be mistaken for a fracture with depression, and so too may an abnormal depression of the skull. Such a depression may depend upon a congenital malformation, or be produced by absorption of the diploë and thinning of the tables, as sometimes occurs in the skull, especially in elderly persons.

Accompanied, however, by a wound leading down to the bone, fractures of the vault are, in general, easily detected; but even here appearances are sometimes deceptive, and sutures and vascular grooves have been mistaken for fissures. In some of these cases the error, no doubt, arose from carelessness; but an abnormal disposition of a suture may mislead the most attentive. And unless careful, even in compound fractures with depression, we may be led into error as to the exact condition of the inner plate of the bone.

There is, however, one sign indicative of fracture of the skull about which one would have thought that no mistake could possibly have occurred. But Maréchal[1] mentions a case in which the inspissated secretion of the frontal sinuses was mistaken for brain-substance, thought to be oozing out of a fracture in this region.

There is also on record[2] a singular instance of the appearances which may lead to an error in diagnosis as to a compound fracture of the skull. A woman was admitted into the Hôtel-Dieu with a wound in the temporal region, accompanied by profuse bleeding. A fragment of bone, several lines in length, was found deep in the wound and quite loose; this was removed, and the finger then passed through

[1] Op. cit., p. 278.

[1] Mém. de l'Acad. de Chir., t. i., p. 247.

[2] Denonvilliers, Thèse de l'App. du Trépan, p. 16.

an opening, the circumference of which was unyielding. The case was at once thought to be one of compound fracture, with separation of some fragments. But it was soon remarked by a bystander, that the fragment of bone which had been removed was dry, and quite white, as if it had been macerated. This led to a more careful examination of the wound, and it was discovered that the supposed hole in the skull was nothing but a laceration of the temporal fascia, and the fragment, the innocent cause of the error, turned out to be simply a piece of bone which, lying on the ground, had been driven into the temple when the patient fell.

In the treatment of fractures of the vault of the skull are involved some of the nicest and most litigated points in the practice of surgery.

And first, as to linear fracture or fissure: unaccompanied by brain-symptoms, such fractures, even when compound, are not to be interfered with; the wound must be treated according to circumstances, and the case carefully watched for some time. Now and then a fissure of the skull, simple or compound, is followed by suppuration between the bone and the dura mater, the symptoms and treatment of which have already been noticed in the subject of "contusion of bone."

A few years back, and it was held that intracranial inflammation would, in all probability, follow a fissure of the skull; and hence the precept of Pott,[1] "that perforation is absolutely necessary in seven cases out of ten of simple undepressed fracture of the skull." But of inflammation following a fissure, one case only was met with in the wards of St. George's Hospital during a period of ten years, and in this case there was a wound leading down to the bone. The case, as in "contusion of the bone," went on well for upwards of a fortnight; and then, on the seventeenth day, came the symptoms of intracranial mischief, and death followed, notwithstanding the application of the trephine.

The principle of non-interference also holds good in a comminuted fracture, even with depression of the fragments, provided there be no wound of the scalp and no symptoms. It is now an established rule in our metropolitan hospitals that simple fractures of the skull with depression and without symptoms are to be left alone. The depression may be so marked as to be easily detected; and yet, so long as there are no symptoms, all operative interference, of whatsoever kind, is carefully to be avoided.

In such a case the recovery may be as rapid and as uninterrupted as if there had been no depression of the bone. But it must not be forgotten that such a depression may at any subsequent period lead to internal mischief of a serious nature; and the patient ought to be put upon his guard as to the risks which he for the future may be subjected to.

But supposing there be a wound leading down to the bone in a depressed fracture without symptoms, what is to be done? Are we to operate at once, or not? The rule is, that we are to operate, and at once. Compound fractures of the skull with depression most frequently lead, as demonstrated by Sir A. Cooper and Sir B. Brodie,[1] to intracranial suppuration; and hence the rule laid down by these celebrated surgeons, that we are to operate to prevent the impending mischief. To this rule, however, exceptions ought to be made. A slight depression, especially when it corresponds to the thicker parts of the injured bone, does not require an immediate operation. Neither does a deep indriving of the bone over the frontal sinuses; but here it must be borne in mind that the sinuses do not begin to make their appearance until several years after birth. And should a compound fracture with depression chance not to fall under the notice of the surgeon until some days after the accident, he ought, if there are no signs of inflammation, to abstain from operating; and all the more readily, if the depression is a broad one, and the fracture comminuted. In such an injury the patient sometimes recovers without any intracranial inflammation. But in the punctured fracture, in which sharp splinters of the inner table are driven down upon, or into, the dura mater, inflammation almost invariably arises sooner or later; and of all compound fractures of the skull, the punctured fracture is on this account the most dangerous, and the one which most imperatively calls for the use of the trephine. And closely allied to these punctured fractures are those in which a clean cut exists in the outer parts of the bone, with a more or less extensive splintering and depression of the inner plate. True it is that there may be some difficulty in such cases in ascertaining the exact condition of the bone; but we may be sure that the two plates are separated from each other, and the inner one splintered and depressed, if we can pass a probe sideways under the outer parts of the cut bone, and then feel the inner plate some distance deeper.

Sometimes, in these compound fractures of the skull, and especially in the punctured fracture, a sharp fragment of bone may be seen sticking in the brain. In such a case,

[1] Injuries of the Head, p. 130.

[1] Med.-Chir. Trans., vol. xiv., pp. 401, 402.

one of Colles's[1] practical precepts is, that all attempts at removal should be postponed for a few days, in order that the cerebral substance around the fragment may have time to consolidate; but in such a case I cannot help thinking that it is better to try and remove the piece of bone, which sometimes, even, comes away readily enough. In these attempts the surgeon should, however, be exceedingly careful; and should he find the fragment, notwithstanding all his care, sinking deeper into the brain, then there is no doubt that he ought at once to desist, and make no further attempt for a few days.

Fig. 117.

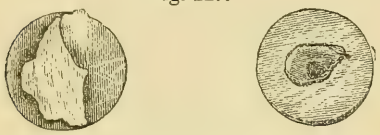


Fig. 117. Represents a button of bone sawed out with a trephine on account of the depression of a fragment by a blow with a stone. Spec. 1452, Sect. I., A. M. M. (See Med. and Surg. Hist. War of the Rebellion, Part I., vol. ii., p. 59.)

Dr. J. L. Van Ingen (N. Y. Journ. of Med., May, 1854, pp. 378–381), in the case of an infant, aged 12 months, that lay totally insensible, with cold skin, no pulse perceptible at wrist and but little in the carotids, breathing scarcely perceptible, and obviously at the point of death from punctured fracture of the right parietal bone caused by falling head foremost upon a projecting tenpenny nail, applied the trephine and raised the depressed bone. Sensibility soon returned, and complete recovery followed.]

In the fractures which we have been considering, operative interference may be, and often is, of essential service; but thus far we have dealt with the most favorable cases only,—those cases in which the injury of the bone was not accompanied by brain-symptoms.

Passing now to those depressed fractures in which there are primary brain-symptoms, are we to operate in all such cases? If the fracture is a simple one, and the symptoms not very urgent, we may postpone the operation, and see what can be done by other remedial measures, before resorting to the trephine. Slight symptoms may perhaps be dependent upon concussion of the brain, or upon some slight pressure, either by blood or by bone; and such symptoms may pass off under the influence of judicious treatment. But if the symptoms are urgent—if they indicate a decided pressure upon the brain—then operative interference becomes necessary.

[Cases illustrative of the value of the rule laid down in the text may be found in the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., pp. 57, 59. See also Am. Journal of Med. Sciences, Oct., 1879, pp. 489 *et seq.*]

And, from what has already been said, it follows that, with a wound leading down to the bone, we ought to operate at once. If the symptoms are slight, the operation may be successful; but if the symptoms are urgent—if compression of the brain is decided and strongly marked—there is every probability that all our efforts will be unavailing: for in such cases it very rarely happens that the brain-symptoms are dependent upon the depressed bone. The severe symptoms in fractures with depression arise, for the most part, from extensive extravasations of blood, or some serious lesion of the brain-substance itself; and hence the reason of an operation being so seldom of any use. Still, notwithstanding all this, it is our duty to operate, as the symptoms may, after all, be wholly dependent upon the bone. Cases are certainly now and then met with in which symptoms of a very urgent nature persist so long as the bone remains depressed, and are relieved only by its removal. Of this, the most remarkable case is Cline's,[1] in which the symptoms continued for the extraordinary period of thirteen months, and still were relieved by the removal of the bone.

As a general rule, a depressed piece of bone may be allowed to remain in a child without producing the serious results so commonly noticed in an adult; and, consequently, we may in a child postpone the elevation or removal of the broken bone, which in an adult we should proceed to operate upon at once.

In operating for a fracture with depression, the only object is to elevate or to remove the fragments which are driven down. Now if this can be done by means of the elevator only, so much the better. Should this not be feasible, then we must see if we can gain sufficient room for the elevator by the removal of a slip of the sound bone overhanging the depressed fragment; and this is to be done by Hey's saw, if possible. The use of the trephine, so far as depressed bone is concerned, is to be restricted to those cases in which the edge of the fracture is regular, and without corners. And in trephining, great care should be taken to remove as little bone as possible; but, in our anxiety not to remove too much, we must be especially careful, and be sure that no irregular margin of the inner plate is left pressing upon the brain. In looking over the skulls in our different museums, it is curious and most instructive to observe how frequently a sharp edge of the

[1] Lect. on Surg., vol. i., p. 173.

[1] Med.-Chir. Rev., vol. i., p. 471.

inner plate of the bone has been left depressed.

[For illustrative cases, see Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., pp. 55, 58. Also, Med. and Surg. Hist. of British Army in the Crimea, vol. ii., p. 295.]

After the removal of parts of the skull, it was the custom in former times to protect by plates of silver, or lead, or by some other means, the portion of brain thus left exposed. Of late years, however, this practice has been abandoned; and now, the protection of the brain is left to the thickened dura mater and integuments, for it rarely happens that ossification takes place sufficiently to fill up the gap. Patients, under such circumstances, may go unharmed for years. Occasionally, however, the cicatrix gives way, hernia cerebri follows, and the patient dies. Thus it happened to a young girl, in a violent fit of coughing, during which the cicatrix suddenly gave way.[1]

[Fig. 118.

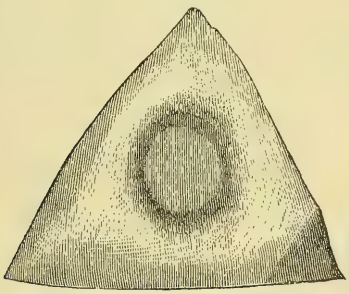


Fig. 118. Exterior view of trephine-hole eighteen years after the operation. Spec. 5024, Sect. I., A. M. M.

In this case (see Figs. 118 and 119) the operation was performed by Dr. Nathan R. Smith, for epilepsy, following com-

Fig. 119.

Fig. 119. Interior view of same specimen, showing the fibroid septum, with its falciform projection.

pound depressed fracture of the right frontal bone, by a blow from a stone, at the depressed part, about three years after the accident. The youth, then aged 15, was comparatively well for six months afterwards; but he gradually became idiotic, while physically he was well developed. He survived the operation eighteen years.

The trephine-hole is 0.625 of an inch in diameter, and is almost closed by a tough diaphanous membrane, having a tendinous lustre, and appearing under the microscope as formed of superimposed layers of horny epithelium. There is a falciform projection from the inner surface of the membrane, which must have pressed upon the cerebral mass (Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 319).]

Finally, in a fracture of the vault, injury of a large venous sinus may occur; and in a compound fracture, such an injury may be followed by hæmorrhage of an alarming character. But, however alarming such bleeding may at first sight be, it is generally said that the danger is more apparent than real; the bleeding may be profuse, but it is easily controlled. Indeed, M. Chassaignac[1] states, that he had not been able to find on record a single instance of fatal hæmorrhage from a sinus thus wounded. There is, however, in the Museum of St. George's Hospital a preparation of a compound fracture of the skull laying open the left lateral sinus (Figs. 123, 124); and in this case, the patient, a powerfully-built man, aged 51, died of repeated attacks of hæmorrhage.

An injury of one of these venous sinuses may also lead to fibrinous deposits within the sinus [thrombosis], and suppuration [puriform softening of the clots], with all its secondary consequences. And pyæmia may, as a matter of course, follow any fracture of the vault; but pyæmia is much more frequently met with in the slighter injuries—scalp-wounds, or contusion of the bone. Thus in twenty-three cases of simple scalp-wound or contusion of the bone, which ended fatally at St. George's Hospital within the space of ten years, purulent infection was noticed in fourteen instances; whereas in seventy-eight cases of fracture terminating fatally within the same period it was noticed in six cases only; and even of these, five were compound fractures. The fact is, that in by far the greater number of fractures the patient dies long before the period at which purulent infection usually sets in.

Fractures of the base. Fractures of the base of the skull are either direct or indirect; that is, the bones either give way at the spot which was actually struck, or at a point more or less remote from the seat of the injury.

[1] Edin. Med. Essays, vol. ii., p. 217.

[1] Des Plaies de Tête, 1842, p. 79.

In the vault, fractures are, as we have seen, for the most part direct; but in the base, direct fractures are, comparatively speaking, very rare.

Fig. 120.

FIG. 120. Compound fracture of the skull, laying open the lateral sinus. *Outer view.*

At certain parts, however, the bones of the base of the skull are remarkably thin and brittle; so thin, that if direct pressure is brought to bear upon them they readily give way. Thus scissors, slate-pencils,

Fig. 121.

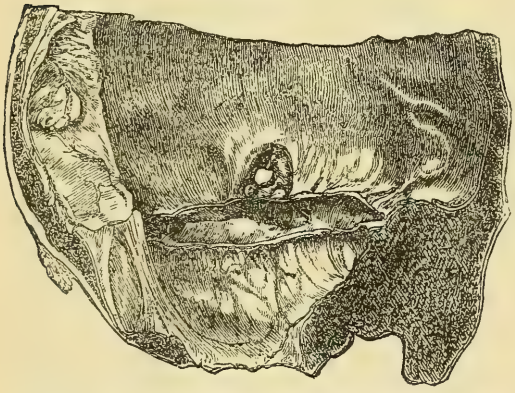


FIG. 121. Compound fracture of the skull, laying open the lateral sinus. *Inner view.*

tobacco-pipes, bayonets, have been thrust into the skull through the orbits, the nostrils, and the occipital bone; and the condyle of the lower jaw has even been driven into the middle fossa of the skull.

Thrust-wounds in these regions, and especially those of the orbits and of the nostrils, are of great importance, from the readiness with which the brain may thus be injured.

Injuries of this kind occur most frequently about the orbits, and in no class of cases is the surgeon more likely to be put off his guard as to the exact nature and extent of the injury. At first, all that may be apparent is the slight injury of the external parts—a trifling wound of the upper lid, and sometimes not even this, for the instrument may have slipped under the lid, and left merely a patch of ecchymosis on the conjunctiva. Brain-symptoms there may be none. Two or three days may pass over, during which the patient goes about as usual; then, brain-symptoms make their appearance, sometimes suddenly, and the patient dies in the course of a few hours, or days, and the true nature of the case is revealed only by the post-mortem examination. Such is the history of the cases recorded by Morgagni,[1] Sir A. Cooper,[2] Sir P. Crampton,[3] Guthrie,[4] and J. Painter.[5] In other cases, recovery has taken place notwithstanding serious injury of the brain, indicated by severe brain-symptoms,[6] or by brain-protrusions.[7] One such case of recovery is constantly quoted, in which it has, however, been made clear that the brain could not have been injured. François de Lorraine, Duc de Guise, is represented[8] as having recovered after a lance had passed immediately *above* the eyeball, and through a part of the skull. But on referring to the report of the celebrated Ambroise Paré,[9] who had charge of the case, it has of late been proved that the lance did not pass *au-dessus*, but *au-dessous de l'œil;* and, consequently, that the skull was not even injured.

What has just been said of direct fractures of the orbit applies equally to thrust-wounds through the nostrils. Whilst fencing with a walking cane with one of his comrades, a soldier was hit on the nose; but the only appearance of injury was a small puncture, not larger than a leech-bite, on the left ala. The man died a few days afterwards, with brain-symptoms; but the exact nature of the case was never even suspected. At the post-mortem examination, however, the brass ferule of the walking-cane was found in the skull, close to the left side of the sella turcica, and this

[1] Letter 51, vol. iii., p. 121.
[2] Lect. on Surg., Tyrrell, vol. i., p. 295.
[3] Dublin Jour., 1851, p. 352.
[4] Injuries of Head, p. 137.
[5] Dublin Jour., 1851, p. 353.
[6] Morgagni, Letter 51, vol. iii., p. 123.
[7] Lancet, 1837–38, vol. ii., p. 16.
[8] Boyer, Mal. Chir., t. v., p. 33, 4e édit.
[9] Œuvres de Paré, édit. Malgaigne, Paris, 1840, t. ii., p. 25.

had led to extensive inflammation of the membranes of the brain.[1]

[A case remarkably analogous to the one above mentioned, is reported in the Med. and Surg. Hist. of the War of the Rebellion, First Surgical vol., p. 33. The specimen is represented in the annexed woodcut (FIG. 122).

Fig. 122.

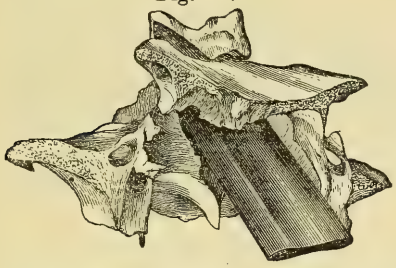


FIG. 122. Transverse fracture of the posterior clinoid process by a sword-thrust through the right nostril. Spec. 1612, Sect. I., A. M. M.]

A direct fracture of the base has also happened by the condyle of the lower jaw being forcibly driven against its fossa, the diaphanous plate of which it has broken through. Of this fracture there is a specimen in the Museum of St. George's Hospital. The bottom of the left glenoid fossa is broken, and the condyle of the jaw projects slightly into the cavity of the skull. But a still better-marked case is that quoted by M. Chassaignac,[2] in which the right condyle of the lower jaw was driven into the skull by a fall from a great height on to the chin. The man lived for between five and six months, during which he always complained more or less of his head, and ultimately died with brain-symptoms. The right condyle of the lower jaw was found pressing against the middle lobe of the brain, in which there was a large abscess.

[A very frequent cause of direct fracture of the base of the skull is the impact of gunshot projectiles. The Med. and Surg. Hist. of the War of the Rebellion contains the histories of a great many cases of this sort; and, strange to say, many persons injured in this way recovered. From these histories the writer has collected one hundred and thirty-five (135) examples wherein recovery more or less complete occurred; a number of which, also, came under his own personal observation. Thirty-five appear to have recovered so fully as to return to duty permanently, or to enter the Veteran Reserve Corps on the one hand, or to be mustered out of, or discharged from, the service *without pension* on the other. At least one of those returned to duty was afterward killed in battle. Two or three recovered so completely as to re-enlist and be accepted. Most of them, however, were discharged from the service and pensioned, their disabilities ranging from one-fourth all the way up to total (Am. Jour. of Med. Sciences, April, 1881, pp. 335–362). It may well be that there is more chance of recovery from gunshot fractures of the base of the cranium than from other fractures of the same parts, other things being equal, because extravasated blood and most inflammatory products can readily escape through the shot-holes in the skull, whereby the occurrence of cerebral compression is happily avoided.]

Fig. 123.

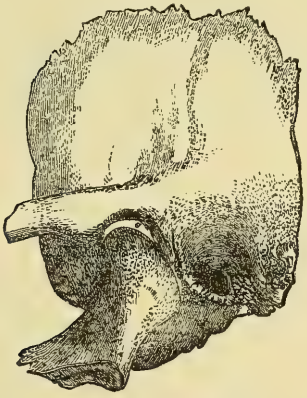
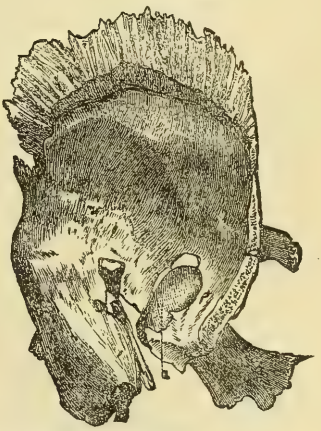


Fig. 124.



FIGS. 123, 124. Fracture of the skull, caused by the condyle of the jaw. *a* shows the condyle projected slightly into the cavity of the skull.
Outer surface. *Inner surface.*

And now as to indirect fractures of the

[1] Dublin Jour., 1851, p. 347.
[2] Plaies de Tête, p. 158; Jour. Hebd., t. iii., No. 37, Sept., 1834.

base of the skull. These fractures are very common; so much so, indeed, that they form by far the greater part of the fatal injuries of the head occurring in our civil hospitals. Such fractures were, for the most part, and for a long time, looked upon as fractures by contre-coup. But modern researches have proved that fractures by contre-coup are very rare at the base of the skull; and a close analysis of fractures of the base shows that the bones of this region may be broken in different ways.

A blow upon the perpendicular portion of the frontal may give rise to a fracture of the orbitar plate of this bone, without any injury whatsoever being perceptible in the intervening osseous tissue. Of this an example happened at St. George's Hospital in the year 1849, and a very similar case is related by Boyer.[1]

The central bones of the base may be the only bones broken when the front and back part of the head have been caught between two opposing forces.

Fractures of the base may also be produced by the force acting from below upwards, the shock being transmitted through the intermedium of the spinal column; and, as in the previous instances, the bones broken may be far away from the spot which was struck. Alighting on the knees, or on the feet, in falls from great heights, gave rise, in one instance,[2] to a breaking off of the apex of the right petrous bone, and of both posterior clinoid processes; in another instance,[3] to a fracture also of the right petrous bone, and a slight fracture of the same side of the sella turcica; and in a third instance,[4] the only bone broken about the skull was the cribriform plate of the ethmoid; every other bone in this region was perfectly sound.

But fractures such as these are, one and all, of rare occurrence, and but very few such cases are recorded by modern surgeons.

Impulsion of the spinal column forcibly against the condyles of the occipital bone is supposed by some surgeons to be the cause of the fractures so frequently observed at the base of the skull. Such was Earle's opinion,[5] and Sir B. Brodie states that his own experience corresponds very nearly with that of Earle; and lately Mr. Hilton, in his valuable Lectures on the Cranium (p. 61), comes to the conclusion that the frequency of the fractures occurring through the petrous bone is dependent upon the forcible impulsion of the spine against the occipital bone.

That certain fractures of the base may be thus produced there is no doubt; but that most of the fractures of this region happen otherwise has, I think, been proved also beyond a doubt. A fracture of the base may be strictly limited to the front,

Fig. 125.

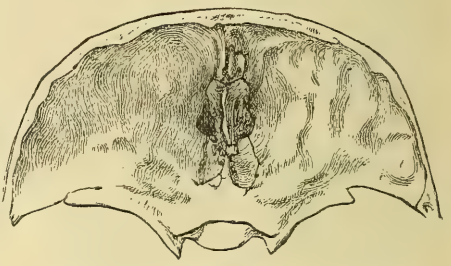


FIG. 125. Fracture limited to anterior fossa.

Fig. 126.

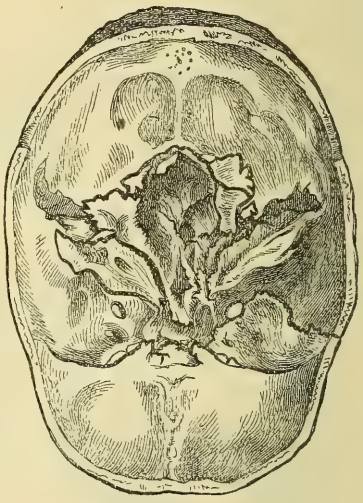


FIG. 126. Fracture limited to middle fossa.

middle, or back part of this region of the skull; and preparations illustrating these different fractures have for many years past been in the Museum of St. George's Hospital. But, as far as I know, M. Aran[1] was the first to prove, by experiments, how certain fractures came to be strictly limited to certain regions. In precipitating a large number of bodies from various heights on to the head, M. Aran found that the part of the vault which first struck the ground gave, as it were, the key to the fracture which would take place at the base. Similar results were also obtained when diffused blows were dealt upon different parts of the skull by means of a large and heavy hammer.

[1] Journ. de Méd., août, 1766, Paris.
[2] Journ. l'Expér., novembre, 1843.
[3] Bull. de la Soc. Anat. de Paris, 1848, p. 193.
[4] Id. 1848, p. 258.
[5] Sir B. Brodie, Med.-Chir. Trans., xiv., p. 329.

[1] Arch. Gén. de Méd., iv^e sér., t. vi., p. 180.

In the front part of the vault, injuries thus produced led to a fracture of the anterior fossa; in the middle part of the vault, they led to a fracture of the middle fossa; and at the back of the head, to a

Fig. 127.

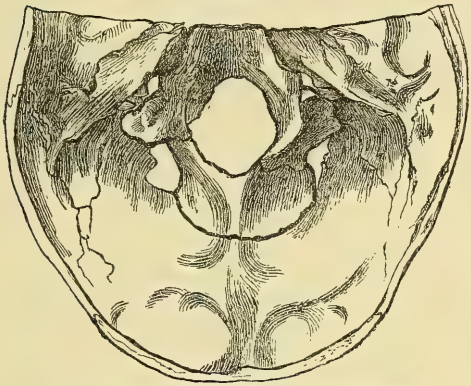


Fig. 127. Fracture limited to posterior fossa.

fracture of the posterior fossa. In no single instance was a fracture detected at the base, without a line of fracture in the corresponding part of the vault.

Taking, then, these experiments of M. Aran's, it will be found that the line of fracture, instead of beginning at the base, starts from that part of the vault which was first struck, and stretches from thence into the base. And the truth of this has been proved by an analysis which I made of all the cases of fractured base of the skull admitted into St. George's Hospital during a period of ten years, in the great majority of which the cause of the fracture was either a fall from a great height, or a blow from some heavy instrument.

But, to trace out these fractures accurately, the skull must be divided into three different zones or segments; an anterior zone, formed by the frontal, the upper part of the ethmoid, and the fronto-sphenoid; a middle zone, by the parietals, the squamous and the anterior surface of the petrous portions of the temporals, with the greater part of the basi-sphenoid; and a posterior zone, including the occipital, the mastoid, and the posterior surface of the petrous portions of the temporals, with a small part of the body of the sphenoid.

With the skull thus divided, the line of fracture, in the less severe cases, is strictly limited to one of these zones. Out of twenty-five cases, the line of fracture was found to be thus strictly limited: to the anterior zone in five cases; to the middle one in fourteen cases; and to the posterior one in six.

In severer cases, the line of fracture starting from the vault spreads into two of the fossæ at the same time, and this is readily accounted for by the position of the middle fossa, which, wedged in between, and firmly articulated with, the bones of the other fossæ, either receives or transmits the injury. Thus, out of twenty-nine cases in which the line of fracture occupied two of the fossæ at the same time, in fourteen it was the middle and anterior fossæ which were implicated; and in fifteen, the middle and posterior.

In the most severe cases, all three fossæ may be implicated at the same time; but, within the ten years, this happened only in ten cases.

Such an analysis points out, moreover, that the middle fossa, either alone, or in combination with the other fossæ, is the region in which fractures most frequently occur. Out of the sixty-four cases, the middle fossa was broken in no less than in fifty-three cases.

In the severer forms of injury there may be, in various parts of the base, some small circumscribed fractures in addition to, and having no connection with, the main line of fracture. Thus, the roof of the orbit is sometimes broken independently of, and away from, the principal fracture; and so, too, may the posterior clinoid processes be thus broken.

[In the case from which FIG. 128 was

Fig. 128.

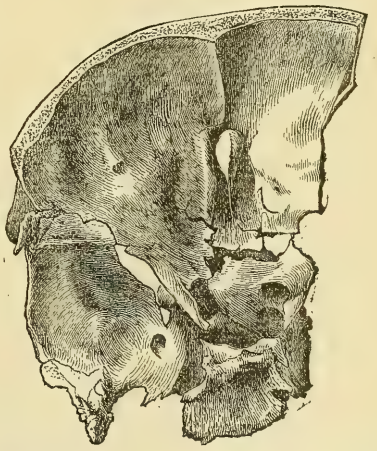


FIG. 128. Fracture of the orbital plate of the frontal, the ethmoid, and sphenoid. Spec. 3440, Sect. I., A. M. M.

taken, death occurred on the seventh day after contusion, inflammatory symptoms having been developed on the sixth day. (Med. and Surg. Hist. of War of Rebellion, Part I., vol. ii., p. 55. See also, Surg. Dict., p. 467, Am. ed.; Trans. N. Y. Patholog. Soc., vol. i., p. 39, and vol. i., pp. 33–35.]

The only *symptoms* that can be depended upon as indicative of fractured base of the skull, are connected either with an escape of some of the contents of the skull, or with an injury done to the nerves as they are emerging from the skull.

The contents of the skull which may escape in the fracture of the base are blood, watery fluid, or brain-substance. The watery fluid and the brain-substance must be left for further consideration, and so, too, must the injury of the nerves. Remains then the escape of blood.

And now, in order that this escape of blood may take place, the line of fracture must run in certain given directions; it must in its course involve some of the large vascular channels lying at the base, and it must, moreover, open a road through which the blood can get out of the skull into some part where its escape may be visible. But should it so happen that the injury does not produce effects such as these, there may be a very extensive fracture of the base, the existence of which cannot be revealed until the post-mortem examination takes place.

A fracture of the base may manifest itself by an escape of blood into the cellular tissue of the orbit and eyelids; by bleeding at the nose, or subsequent vomiting of blood; by bleeding from the ears; by an escape of blood into the cellular tissue in the mastoid region, or into that of the back of the head.

A fracture involving the orbitar plates of the frontal, and extending into the sphenoid, may lay open either the venous channels in this region, or the ophthalmic artery—the former much more commonly than the latter.

The blood, at first poured out at the back of the orbit, soon makes its way forward; readily infiltrating the loose cellular tissue of this region, it shows itself under the ocular conjunctiva and subsequently spreads into the eyelids. First the ocular conjunctiva, then the lids; such are the points at which blood coming from the bottom of the orbit must show itself. But it is the effusion of blood under the ocular conjunctiva which must guide us in our diagnosis, and for this purpose the effusion must not consist of a few patches only; it must extend into the cellular tissue of the orbit beyond our sight. As to the lids, the lower one generally becomes discolored before the upper one. M. Velpeau thinks that the lower lid is always the first to be discolored; but I have seen several cases of fractured base in which the ocular conjunctiva and the upper lid were ecchymosed without any discoloration of the lower lid.

Effusion of blood under the ocular conjunctiva is, then, the sign by which a fracture of the base may be recognized. But a fracture of this region may exist without any effusion of blood under the ocular conjunctiva, or the lids only may be discolored; and in such cases it must be borne in mind that, however, extensive the fracture, it cannot be diagnosed.

Out of twenty-three cases of fractured base, involving more or less extensively the orbitar plates of the frontal, all of which occurred at St. George's Hospital within the space of ten years, it was found, in eight cases, that there were no traces of extravasated blood to be seen either in the eyelids or under the ocular conjunctiva; and in five cases, that the effusion of blood occupied the eyelids only: so that in these thirteen cases there could have been no suspicion whatever as to the existence of a fracture. But, on the other hand, the nature of the injury was made manifest in the ten remaining cases by the blood effused under the ocular conjunctiva and in the lids.

Blood may, however, be effused into the lids, and under the ocular conjunctiva, in fractures of the malar, or of the superior maxillary, bones; and this may give rise to an error in diagnosis. But such cases are of rare occurrence. One was published some few years back by Mr. Holmes.[1]

[Dr. Hodges points out (Boston Med. and Surg. Journal, April, 1873), that ecchymosis of the eyeball is of value as a sign of fracture of the base of the skull, and sums up as follows: 1. An effusion of blood beneath the scalp, if it does not gravitate backward, often produces an ecchymosis in the cutaneous surface of the eyelids, but never in the conjunctival surface of the lids or of the globe. 2. A blow directly upon the eyeball may give rise to an ecchymosis of the conjunctiva, both of the globe and lids. 3. Where fracture of the base of the skull is indicated by ecchymosis, this ecchymosis appears first beneath the conjunctiva of the globe, then beneath the palpebral conjunctiva, and only subsequently in the integument of the lids, if at all. 4. When the injury has been such as to make a fracture of the cranial base probable, external ecchymosis of the lower lid, and less frequently of the upper lid, is a significant symptom only when it accompanies ecchymosis of the globe, or follows it after an interval.]

Effusion of arterial blood at the back of the orbit, in consequence of a fractured base, is of further interest, inasmuch as it may ultimately lead to a traumatic aneurism, which may go on increasing in size, and thus imperatively call for surgical interference.

Three such cases have occurred, within

[1] Association Medical Journal, 1855, p. 967.

the last few years, to London surgeons; two at the London Hospital itself, and one at the Seamen's Hospital. In all these three cases, the history and the symptoms left no doubt as to the nature of the injury; in all three, a ligature was ultimately applied to the common carotid, and in all three recovery followed this operation.[1]

Bleeding from the nose or mouth, or vomiting of blood, occurs, not unfrequently, after injuries of the head; but the great vascularity of the membrane lining these cavities renders this bleeding much less valuable as a diagnostic sign of fractures of the base than that which proceeds from the ear. Still, if the bleeding be copious, and especially if it continue for some time, there is no doubt that it then becomes a symptom of great value as a means of diagnosis. Out of thirty-two cases of fractured base, implicating the central bones of this region, all of which occurred at St. George's Hospital in the space of ten years, bleeding from the nose or mouth, or subsequent vomiting of blood, was present in no less than in fourteen instances. The symptoms in these cases were such as to lead to the belief that a fracture existed in some of the bones of the base corresponding to the pharynx or nose; and dissection proved that out of the fourteen cases, the fracture was confined in four cases to the ethmoid; in three, to the body of the sphenoid; and in one, to the basilar process. In five cases, the fracture involved both the ethmoid and the sphenoid; and in one case it extended not only through these bones, but through the basilar also.

In the vomiting of blood, proceeding from a fractured base, it not unfrequently happens that the fluid thrown up is of a dark bistre color; having been swallowed and retained in the stomach for some time, the blood has, in fact, been more or less acted upon by the gastric juice. Such appearances I have several times noticed when vomiting occurred after the subsidence of the symptoms of concussion which accompanied the fractured base.

Bleeding from the ears, in severe injuries of the head, has, for many years past, been held, and deservedly too, as one of the most valuable diagnostic signs of fractured base. But this bleeding, to be of any value as a means of diagnosis, must be of a serious nature, and, above all, it must continue for some time. With such a bleeding, it may be safely diagnosed that there is a fracture of the base running through the petrous bone, and opening up a communication between the cavity of the tympanum and some of the numerous and large vascular channels which surround this bone, or with an extravasation of blood within the cranium itself.

Out of thirty-two carefully dissected cases of fracture of the middle fossa implicating the petrous bone, the flow of blood from the ear was profuse and continuous in fifteen cases, and in all these cases the diagnosis of the injury was clear.

On the other hand, fractures of the temporal bone frequently occur in which there is no sign that can lead to the supposition of such an injury. In such cases, either the line of fracture does not extend into the tympanum, or, if it does, the membrana tympani is not ruptured, and the blood cannot consequently get into the external meatus. Thus, in twelve of the seventeen remaining cases, the tympanum was not involved in the fracture, and in the other five cases the tympanum was fractured, but the membrana tympani was not ruptured.

In those cases in which a fracture of the petrous bone communicates with one of the venous sinuses on the inside of the skull, and in which there is no rupture of the membrana tympani, there can be no bleeding from the ear; but, in such cases, the blood poured into the cavity of the tympanum soon finds its way through the Eustachian tube, so that there may be bleeding from the nose or from the mouth, or subsequent vomiting of blood. Of this, careful dissections leave no doubt. And this passing of blood from the cavity of the tympanum through the Eustachian tube may even take place when there is a rupture of the membrana tympani; so that, in some few cases of fractured petrous bone, we may actually have bleeding both from the ear and from the nose at the same time.

Extravasation of blood, and consequent discoloration of the skin, appearing in the mastoid region some hours after a severe injury of the head, may lead to the suspicion of a fracture involving the posterior part of the base; and all the more valuable will this sign become, if the injury did not bear directly upon this region, and especially if it bore upon the opposite side of the head.

A discoloration of the integuments of the lateral parts of the neck, appearing subsequent to an injury of the head, may also serve as a guide to the diagnosis of a fracture of the base. The blood oozing from the fractured skull gradually infiltrates the cellular tissue of the neck, and thus ultimately reaches the skin, which becomes discolored, as if bruised.

And a sudden puffiness in the occipital region, with discoloration of the skin, some hours after a severe injury on this part of the head, may also be of use in the diagnosis of a fractured base. The large ven-

[1] Med.-Chir. Trans., vol. xxii., pp. 124–134; xxxvi., p. 221.

ous sinuses connected with the occipital may, when this bone is broken, be torn across, and thus give rise to an extravasation of blood, which gradually oozing through the line of fracture, may ultimately show itself in the superficial parts, and thus reveal the nature of the injury.

Fractures of the base of the skull, even when clearly recognized, lead but very seldom to operative interference. All our treatment must be directed, not against the broken bones, but against the accompanying cerebral lesions. In some rare instances we may, however, have to resort to an operation, even in the base of the skull. Thus in a comminuted fracture, with depression, I have seen a fragment removed which proved to be the greater part of the roof of the orbit. And the trephine has been applied, and successfully too, close to the foramen magnum.[1]

[See Med. and Surg. Hist. of War of Rebellion, Part I., vol. ii., p. 57, 60.]

What occurs about the broken bones, when the patient survives a fractured base? Does union take place? And if so, by what medium are the broken bones united?

In some cases, even after a lengthened period—months, and years—no trace of union has been found. In other cases, the line of fracture has been found united partly by dense fibrous tissue, and partly by a thin layer of inlaid bone. And in other cases, again, bony union has been perfect, and throughout the whole line of fracture. In some cases of bony union, porous bone has been found heaped up along the sides of the line of fracture on the inner side of the skull; and when the fracture passes through one of the sinuses, this heaping up of bone may be such that the channel becomes blocked up.

Separation of the sutures.—A question has arisen whether a separation of the sutures can possibly occur, without the bones being in some way or other broken. As might well be supposed, from the nature of the articulations about the skull, a separation of suture without a fracture is a very rare form of injury. I have observed it but once. It occurred in the back part of the squamo-parietal suture. The temporal having been slightly separated from the parietal, and driven upwards, these bones presented at first sight the appearance of a fracture with depression.

In every other case in which I have met with separation of the sutures, it has always been in connection with extensive fractures stretching into the base. Thus, in seventy-eight cases of fractured skull, there were fourteen cases in which there was extensive separation of the sutures, two or more of which were sometimes implicated at the same time.

As to the frequency with which the various sutures give way, an analysis of these fourteen cases proves that separation of the coronal suture occurred in seven cases; in the lambdoid, it occurred in six cases; in the sagittal, in four; in the petro-occipital, in one; in the temporo-parietal, in one; and in the spheno-parietal, in one. It sometimes happens, when several sutures have given way at one and the same time, that a whole bone becomes detached from the other bones. Thus, in one case where there was complete separation of the coronal suture, the frontal was at the same time extensively separated from its connections with the other bones of the skull, and thus all but isolated.

This separation of the sutures is, as a matter of course, most likely to occur before the adult period of life, and when the bones have not been soldered together. It has, however, happened at an advanced age, as proved by a case of Morgagni's,[1] in which the patient was sixty years old.

Coexisting, as separation of the sutures for the most part does, with extensive fracture of the base, this injury must be classed among the most dangerous to which the skull is subject. It invariably indicates that great violence has been done to the bones. Oftentimes it is accompanied by laceration of the pericranium, and separation of the dura mater; sometimes even by extensive laceration of both these membranes, through which the brain-substance may be squeezed out of the skull, and found lying immediately under the integuments.

A most extensive separation of the sutures, with fracture of the bones, may, however, take place without any injury of the cerebral substance. Of this, I once dissected a most remarkable instance. The skull was extensively broken; the two parietal bones were widely separated from each other, and on a different level in the whole length of the sagittal suture; the left bone was in its natural position, but the right was driven down about two lines. The brain itself was not in the slightest degree injured.

Disjunction of the sutures, in its symptoms and treatment, cannot be separated from fractures of the skull.

[Quesnay (op. cit., p. 8) mentions the case of a man treated by Mouton, who had sustained separation of the sagittal suture in consequence of a fall. Trephining gave vent to a great deal of extravasated blood, the threatening symptoms immediately ceased, and the man got well.

Guthrie (Commentaries, etc., pp. 349, 350, Am. ed.) relates the case of a dragoon

[1] Med.-Chir. Trans., vol. ii., p. 105.

[1] Letter 51, art. 28.

who sustained separation of the sagittal suture by falling from his horse on to the top of his head. After trephining permitted the extravasated blood to escape, he gradually recovered.

Of course the base of the cranium was not fractured in these cases. The parietals separated, one from the other, at the sagittal suture, with laceration of the superior longitudinal sinus, and extravasation of blood between the bone and the dura mater. On freeing the brain of compression by trephining, both patients readily recovered.]

Watery Discharges in connection with severe Injuries of the Head.

As an accompaniment of severe injuries of the head, a thin watery fluid is now and then found issuing either from the ear, or from the nose, or from some part of the vault of the skull.

From the ear. The watery discharge from the ear is that most commonly met with. As early as the year 1727, Stalpartius van der Wiel[1] published a case in which large quantities of a thin, clear, watery fluid had escaped from the ear, for several days, after a severe injury of the head. This case, and another quoted by Stalpartius from Joël Langelottus, are the only cases usually referred to as having been observed by the older surgeons; but O'Halloran,[2] some thirty years later, also published a case of the same nature, and in some respects even more characteristic; and the elder Dease[3] appears likewise to have been well acquainted with the occurrence of this peculiar watery discharge from the ear. But, notwithstanding the striking nature of these facts, the subject was subsequently lost sight of until some forty years back, when M. Laugier,[4] by some carefully-made dissections, first brought to light the coexistence of this watery discharge from the ear with a fracture of the petrous bone and a rupture of the membrana tympani; and then followed the question, even now so much debated, as to the possible source of this fluid.

The various opinions which have been broached upon this point may, however, be reduced to two classes: one in which the fluid is said to be nothing but the serum of the blood; the other, in which it is said to be the secretion from some membrane.

This fluid was at first thought to be nothing but the serum from a clot of extravasated blood lying over and in direct contact with the fracture. Such was Laugier's first opinion, published in 1839, to which he has latterly added the "exudation of serum from lacerated vessels lying along the broken bone, and the neighboring soft parts."[1] M. Chassaignac also thought that the fluid is due to the serum of the blood, but that it oozes through a fraying of the thin outer wall of some one of the large venous sinuses connected with the petrous bone.[2]

Neither of these opinions has, it must be confessed, been borne out by subsequent experience.

The fluid has, in turn, been ascribed to one of the several secreting membranes with which the petrous bone is so closely connected. It has been thought to be the liquor Cotunnii; the fluid from the cavity of the arachnoid; then, again, the cerebro-spinal fluid.

That the discharge is due, in some cases at any rate, to the escape of the cerebro-spinal fluid, there is now no longer any doubt. First mooted by Auguste Bérard and M. Nélaton,[3] this opinion was subsequently taken up and thoroughly investigated by M. Robert.[4] Anatomy, dissection of morbid specimens, experiments on the dead subject, all led to the conclusion that the watery discharge from the ear, after a severe injury of the head, is due to the escape of the cerebro-spinal fluid. And M. Chatin,[5] in analyzing this watery discharge, found its composition to be the same as that of the cerebro-spinal fluid, both being especially marked by the very small quantity of albumen and the large quantity of chloride of sodium.

The escape of the cerebro-spinal fluid implies a fracture cutting across the meatus internus and communicating with the tympanum, a laceration of the tubular sheath of the cerebral membranes surrounding the seventh pair of nerves within the meatus, and laceration of the membrana tympani. Of these various lesions, the only one about the proof of which there has been any difficulty is the laceration of the cerebral membranes within the meatus. There is, however, in the Museum of St. George's Hospital, a preparation which I dissected some years back, and which leaves no doubt upon this point.

But there are many cases in which dissection proves that the fracture has nothing to do with the meatus internus; whatever its course, either across or perpendicular to the axis of the petrous bone, the fracture passes through the internal and middle ear without touching the meatus. In such cases, it is clear that the watery discharge cannot be due to the escape of

[1] Observat. rarior. cent. prior., obs. xv.
[2] Injuries of the Head, p. 120.
[3] Colles's Lect., by McCoy, vol. i., p. 155.
[4] Comp. Rend. de l'Acad. des Sc., 1839, p. 240.

[1] Arch. G. de Méd., iv^e sér., t. viii., p. 413.
[2] Mém. de la Soc. de Chir. de Paris, tom. i., p. 542.
[3] Compend. de Chir. Prat., t. ii., p. 591.
[4] Mém. de la Soc. de Chir. de Paris, t. i., p. 562.
[5] Id., p. 568.

the cerebro-spinal fluid. It is then said, by many surgeons,[1] to be the liquor Cotunnii proceeding from the membrane of the labyrinth; and difficult, indeed, would it be, in many cases, to prove that the watery discharge is not in part due to this fluid, where the fracture runs through both the internal ear and the tympanum, which are thus made to communicate with each other, their investing membranes being torn. In opposition to this view, we have, however, the quantity of the fluid, which oftentimes is so great that we can scarcely realize the idea of its being all furnished by a membrane of so limited an extent. And to this we may add those cases of profuse watery discharge from the ear, after a severe injury of the head, in which it has been proved that there was no fracture involving either the internal or the middle ear, and no communication whatsoever between these cavities.

Such a case occurred at St. George's Hospital in the year 1854. The man, having fallen off a ladder about twenty feet high, was admitted with a discharge of bloody fluid from the left ear, and a scalp-wound, not exposing the bone, at the upper and back part of the head. He died on the seventh day after the accident, with diffuse cellular inflammation of the scalp, and symptoms of cerebral mischief. As to the fluid from the ear, on the morning following the accident it was of a roseate hue, and flowing so freely that in less than an hour a couple of ounces were caught in a gallipot placed under the ear. The discharge went on thus for two days, the pillow-case being so soaked that it became necessary to have towels placed under the head. On the third day, the fluid was much less in quantity, and on the sixth there was but little of it, and it was of a puriform appearance. The temporal bone was carefully, and at several different times, examined both by Mr. Henry Gray and by myself. There was no fracture, and no injury whatsoever of the bone itself; there was no kind of communication between the middle and the internal ear; the membrane lining the cavities of the internal ear was perfectly natural in every respect; the membrane lining the cavity of the tympanum and the mastoid cells was intensely vascular throughout, and covered with a muco-purulent secretion; the membrana tympani was extensively ruptured at its anterior and inferior part. The case has been recorded by Mr. Henry Gray in the Transactions of the Pathological Society of London, vol. vi., p. 22. In this case there was no fracture; the watery discharge could not, then, be due either to the escape of the cerebro-spinal fluid or to an increased secretion from the arachnoid, or to a filtration of the serous part of the blood. There was no communication between the middle and the internal ear; it could not, therefore, be due to the escape of the liquor Cotunnii. But there was a rupture of the membrana tympani, and the membrane lining the cavity of the tympanum was intensely vascular; and this, I think, proves that, in this case, at any rate, the fluid proceeded from the inflamed membrane of the middle ear.

Another case of copious watery discharge from the ear, after an injury of the head and without any fracture of the temporal bone, occurred at St. George's Hospital a few years ago. The man was admitted with bleeding from the ear, which was followed by a copious watery discharge. He died; and on dissecting the temporal bone most carefully, Mr. Holmes could find no fracture in any part of it, and no injury whatsoever either in the tympanic cavity or in any part of the internal ear. The discharge was connected with fracture of the lower jaw just below the condyle: the lower fragment had perforated the wall of the meatus auditorius.

I have mentioned these two cases particularly to prove that cases do, now and then, occur in which an injury of the head has been followed by a copious watery discharge from the ear, without any fracture or injury about the petrous bone, or any communication between the middle and the internal ear.

What value, then, are we to attach at the present time to the watery discharge from the ear as a diagnostic sign of a fracture of the base? Can it now be said that a profuse watery discharge from the ear, after an injury of the head, is pathognomonic of fracture of the petrous bone? It must be confessed that we cannot say this. On the other hand, however, there is no doubt that the symptom still remains as one of great diagnostic value under certain circumstances.

A close examination of these cases of watery discharge shows that this fluid makes its appearance under different circumstances. In some cases, no discharge of blood, or only a very small quantity, precedes that of the watery fluid; the discharge is, in fact, watery, and unmistakably so, immediately after the accident. In other cases, a copious flow of blood, going on for some hours, precedes the watery fluid. In other cases, again, the flow of blood is decided, but to no great amount, and for no long period; and then, sooner or later, comes the watery discharge. There are, then, as far as is known at present, three classes of cases of this watery discharge.

In the first class, where the fluid from the ear is plentiful, and of a decidedly watery character immediately after the accident, there need be no doubt as to the nature of the injury,—the watery discharge is due to the escape of the cerebro-spinal fluid, which, as already stated, can only take place through a fracture of the petrous bone implicating the internal auditory canal and its membranes.

In the second class of cases, characterized by a copious and prolonged bleeding from the ear, followed by a watery dis-

[1] Dict. de Méd., 2e édit., t. xxix., p. 570.

charge, a fracture of the petrous bone may also be safely diagnosed; but it cannot be said that the fracture follows any particular course. In these cases it must, however, be clearly understood, that it is not to the watery discharge that we can trust for our diagnosis, but to the copious and prolonged bleeding.

Thus far there is no difficulty. Not so, however, in the third class of cases, in which there is at first a discharge of blood only, neither copious, nor prolonged, which is followed by a watery discharge, varying as to the time of its appearance—varying as to its quantity. It may be present within a very few hours after the accident, —it may be profuse within a very few hours after its appearance. These are the cases in which experience has, of late, proved that the diagnosis ought to be doubtful. The discharge of blood is certainly not of a character to warrant a diagnosis of fracture of the petrous bone; and as to the watery discharge, it is now well known that such a discharge may occur within a few hours after the accident, that its quantity may even be profuse, and yet that there may be no fracture.

It has been stated by some surgeons abroad, and especially by M. Robert,[1] that this profuse watery discharge, after an injury of the head, belongs especially to childhood and youth; but the cases which have fallen under my own notice, it so happens, have been for the most part beyond thirty years of age.

A profuse watery discharge from the ear has always been held as one of the very worst features in an injury of the head. At one time, indeed, so bad was this feature thought to be, that it was said that no patient ever recovered who presented this symptom. Such, in former years, was the opinion of the elder Dease,[2] and such, even in later years, was at one time the opinion of M. Robert.[3] But Stalpartius's first case, in which, after an injury of the head, complete recovery took place, notwithstanding a most profuse discharge of a watery fluid, had evidently been forgotten for a time; and, of late years, several cases of recovery have been recorded.

In recording cases of recovery after this profuse watery discharge from the ear, we must, however, for the future bear in mind carefully to note the precise circumstances under which the discharge took place, and especially the precise characters of the fluid from its very first appearance. It must be particularly stated whether the fluid was watery from the beginning, or whether it was merely bloody; and then, whether the flow of blood was continuous for any length of time. And unless these points are carefully looked to, there will be some doubt as to recovery having taken place after a fractured base.

From the nose. A discharge of a watery fluid sometimes takes place from the nostrils, after a severe injury of the head; but such a discharge occurs much less frequently from the nose than from the ear.

Attention was first called to this subject by a case which was under the care of Blandin, at the Hôtel-Dieu, in the year 1840.[1] The actual source from whence this fluid came was not clearly made out in this case; but in M. Robert's case,[2] which occurred in 1845, a careful examination proved that the dura mater lying over a fracture of the sella turcica was torn to the extent of about an inch, and that the visceral arachnoid corresponding to the anterior lobes of the brain was also torn. Moreover, some water dropped on to the sella turcica soon made its way into the nostrils, and, more especially, into the right side.

What are the characters of this watery discharge from the nostrils? Whenever carefully examined, the characters of this fluid have been found to be precisely similar to those of the profuse watery discharge from the ear belonging to our first class of cases. The fluid, then, is marked by its limpidness, and by its containing a large quantity of chloride of sodium, and little or no albumen; in fact, it is of the same nature as the cerebro-spinal fluid. M. Chassaignac,[3] however, sees here, as he did in the ear, nothing but a filtration of the serous part of the blood contained in the numerous venous sinuses in close connection with the body of the sphenoid, the fluid escaping from the sinuses through a fraying of their walls. But here again, the chemical analysis of the watery discharge differing so widely from that of the serum of the blood, makes it impossible to admit that such can be its source. Whence, then, does this fluid come? The anatomical disposition of the cerebral membranes in the central parts of the base of the skull is such that, doubtless, a fracture of this region might involve the membranes, lay open the great reservoirs of fluid contained in the corresponding subarachnoid space, and thus account for the enormous discharge of watery fluid observed in these cases; and which in M. Robert's case flowed in large quantities after death, upon the body being turned with its face downward. And in addition to the subarachnoid space, situated over the body of the

[1] Arch. Gén. de Méd., iv^e sér., t. ix., p. 407.
[2] Colles's Lectures, by McCoy, vol. i., p. 155.
[3] Arch. Gén. de Méd., iv^e sér., t. ix., p. 409.

[1] Gazette des Hôpit., 1840, p. 205.
[2] Loc. cit., p. 590.
[3] Loc. cit., p. 553.

sphenoid, there is also here, in the sella turcica, the pituitary gland, connected with the infundibulum, which is continuous with the third ventricle. So that at this spot the watery discharge from the nostrils might be due to the escape of the fluid contained in the ventricles, if the pituitary gland and infundibulum were lacerated or destroyed by the injury. And such, one may infer from the post-mortem appearances, was the nature of Blandin's case.

But it would also appear that, every now and then, this watery discharge from the nostrils may be connected with a fracture of the petrous bone. As the blood in a fracture of the petrous bone sometimes escapes through the Eustachian tube, so may the cerebro-spinal fluid poured into the cavity of the tympanum through a fracture implicating the internal auditory canal escape thus. One such case has been published by Dr. Foucard,[1] and another by M. Malgaigne,[2] in which a most copious watery discharge took place both from the ear and from the nostril, at the same time.

In dealing with this watery discharge from the nostrils as a diagnostic sign of a fractured base, it must, however, be borne in mind, that not unfrequently a copious watery secretion, perfectly clear and limpid, is poured out by the pituitary membrane itself. Some persons, indeed, are subject to periodical attacks of this kind, during which a perfectly clear fluid is poured out from the nostrils, in very large quantities, and for several hours together; and this it is which makes it so difficult in some cases, evidently of fractured base, to give any opinion as to the source of the watery discharge which has existed.

From the vault of the skull.—A discharge of a clear, watery fluid, precisely similar in its character to the watery discharge from the ear and from the nose, may also take place from any part of the vault of the skull, provided the injury extend not only through the integuments and the bones, but also through the cerebral membranes; laying open, in fact, the space between the visceral arachnoid and the pia mater.

The watery discharge in these cases, as in some of the cases connected with the ear and with the nostrils, is due, then, to the escape of the cerebro-spinal fluid.

In his valuable paper on the subject of watery discharges from the head after injuries, M. Robert states, that the first case of watery discharge from the vault which fell under his notice occurred in the year 1847; and that, until he had seen this case, he had always thought that these watery discharges existed only in fractures of the base of the skull.[1]

Cases of a watery discharge from the vault in compound fractures had, however, been noticed by some of our predecessors years ago; but the facts, as in the case of a watery discharge from the ear, remained buried in oblivion until the attention of the profession was especially directed to them by the many discussions to which this subject has of late years given rise.

The earliest published case of this watery discharge from the vault is dated as far back as the year 1672. The child, about seven years old, was under the care of Delamotte; nothing untoward occurred, and in about a month's time the wound was perfectly healed. The fact of a watery fluid having been discharged through the wound is not mentioned in the history of this case; but, in his accompanying observations, Delamotte expressly states that he very much wished to apply the trepan in this case, and especially on account of a long kind of sinus leading from the wound on the forehead deep into the inside of the skull, from whence flowed a large amount of watery fluid, the quantity of which was much increased each time the boy was made to blow his nose.[2]

In a case which was under the care of Hey, of Leeds,[3] in 1809, a watery fluid issued from a compound fracture of the forehead so copiously as to wet the child's nightcap considerably. The discharge gradually abated, and ceased about the end of three weeks.

In Dr. O'Callaghan's case[4] there was also a copious flow of bloody serosity from a wound connected with a fracture of the frontal bone; and in Dr. Hofling's case[5] a compound fracture of the frontal bone was followed by a clear, watery discharge, which soaked through all the dressings, and oozed copiously and uninterruptedly for the space of eight days. Dr. Hofling published this case as one of chronic hydrocephalus luckily cured by the kick of a cow; but in the details of the case there is certainly nothing to prove that the child was threatened with the hydrocephalic affection which is said to have been impending.

But two of the most curious cases of watery discharge from the vault occurred after trephining for epileptic fits, apparently connected with injuries of the head. In one of the cases, Professor Dudley states that the watery discharge went on for three days and nights, and was so copious as to make it necessary to change towels, pillows, bolsters, and sheets, two or three times a day; and it was computed that the entire amount of the fluid discharged could not have been less than two gallons; and notwithstanding all this, the patient recovered.[6]

In M. Robert's case,[7] the draw-sheet was completely soaked through during the night; and, on the following morning, the lips of the

[1] Journ. de Chir. de Malgaigne, 1846, p. 315.
[2] Ibid., p. 283.

[1] Loc. cit., p. 596.
[2] Mauquest Delamotte, Traité Comp. de Chirurg., vol. i., obs. 145, p. 544.
[3] Surgery, p. 21, case 5.
[4] Dub. Med. Press, vol. xiii., p. 81.
[5] Arch. Gén. de Méd., Nov., 1837.
[6] Amer. Journ. Med. Sc., 1828, vol. ii., p. 491.
[7] Loc. cit., p. 596.

wound were found to be slightly united, except at the posterior angle, where there was a small opening, through which was flowing a clear, watery fluid, perfectly limpid, and saltish to the taste. On the third day the watery discharge had ceased, the wound having united in its whole length; but shortly afterwards the wound gave way at its posterior angle, and the fluid immediately reappeared, and continued to flow for two days, when it finally ceased. The man ultimately got well.

In the seven cases above alluded to, there is every reason to believe that the fluid was the cerebro-spinal fluid from the subarachnoid space; but there is no doubt that the watery discharge from the vault may proceed from the lateral ventricle. This has been proved by dissection, in a case where, after extensive sloughing of the brain, the parts had become covered with granulations; everything was apparently going on well, when a discharge of a watery fluid occurred from the wound; the fluid, perfectly clear and limpid, was traced to a minute opening buried in the midst of the granulations, from whence it came away in drops, and sometimes in a jet, at each pulsation of the brain. The man ultimately died; and at the examination of the head, the minute opening through which the watery discharge had taken place was found to lead directly into the left lateral ventricle, the fluid of which had thus escaped.[1] And it was from the ventricle, I think, that the fluid came in the case mentioned by Mr. Erichsen,[2] to whom I am indebted for the following additional notes. It was not till the nineteenth day after the accident that the fluid made its appearance; it came suddenly, and was discharged in such quantities that the pillow was completely saturated with it during the course of the night; after this the boy lived four days, during which large quantities of the same transparent fluid continued to flow from the wound; and, even on the day of his death, the fluid was still running profusely. Unfortunately, there are no notes as to any examination of the head in this case; but, with such a history, I think it more than probable that the fluid did not proceed from the subarachnoid space, but from the right lateral ventricle, the posterior horn of which, thinned by an accumulation of fluid, gave way, and thus allowed of the profuse watery discharge, which suddenly took place on the nineteenth day after the accident.

Another case in which the fluid also came, in all probability, from the lateral ventricle, has, since the above was published, been under my own care, in St. George's Hospital. It was that of a boy, aged seven years, who having just been run over by a light brougham, was admitted, in March, 1863, into the hospital, with a compound fracture of the right parietal, about two inches and a half above the ear. A triangular piece of bone had been completely broken off, and driven down, so as to be buried in the brain, and serous fluid was oozing through the wound. As the bone could just be felt with a probe, it was laid hold of with a pair of dressing forceps, and pulled out; it measured about an inch and a half in length, and being turned lengthways, it had, in all probability, torn the lateral ventricle, from whence came the fluid, which soon became perfectly clear and limpid, and went on increasing in quantity, so that on the second day after the accident, in addition to a quantity which was lost, no less than four ounces and a half were collected within twenty-four hours. The fluid went on running thus until the sixth day after the accident, soaking the towels under the side of the head, when it began to diminish somewhat in quantity, and, on the tenth day, it was reduced to an occasional drop running down the cheek. Matters went on thus for a few days more, when the fluid ceased altogether, and the child was discharged from the hospital, cured, with the wound completely healed, seven weeks after his admission. I have seen this boy again lately, that is six years after the accident, and, barring the gap in his skull, where the brain can be felt pulsating, there is nothing the matter with him.

A case of escape of cerebro-spinal fluid, in connection with a simple fracture of the frontal bone just above, and including the orbitar arch, has just been published by Mr. Warrington Haward,[1] which presents peculiar features. As the fracture was not compound, the fluid escaping under the integuments formed a transparent pouch, with distinct pulsation, in the region of the blow, and in four or five days great swelling of the upper eyelid, and eversion of the palpebral conjunctiva. The tumor was ultimately punctured with a very fine trocar, and eight ounces of clear fluid were drawn off, leaving the sac empty, but it soon filled again, the little wound having been closed up. On the eighth day after this, the everted conjunctiva gave way, and a large quantity of clear fluid escaped, and went on running, so that it was computed that about a pint of fluid was thus lost in twenty-four hours. The child ultimately died of cerebral symptoms, but the only part of the body of which the parents would allow an examination was the portion of broken bone, where a gap was found between the fragments, and here there was a rent in the membranes, through which the handle of a scalpel was easily passed into the brain.

What influence is the escape of the cerebro-spinal fluid through a fracture of the skull likely to exercise on the ultimate issue of the case?

Looking to fractures of the base only, it might at first sight be supposed that the escape of the cerebro-spinal fluid would exercise a most dangerous influence on the progress of the case. It cannot in truth be said, however, that the danger in these cases is dependent upon the escape of the cerebro-spinal fluid. The danger lies not in the gradual loss of the fluid, but in the severe lesions, extravasations of blood, and injuries of the brain-substance, which so commonly accompany a fractured base.

But, in looking to the compound fractures of the vault of the skull, in which the brain is oftentimes not injured, there we shall find that large quantities of this

[1] Bulletin de la Soc. Anat. de Paris, année 1838, vol. xiii., p. 13.
[2] Surgery, 2d ed., p. 276.

[1] Lancet, July 17, 1869, p. 79.

cerebro-spinal fluid may be lost, and that apparently without influencing the case very materially.

Out of the eleven cases of watery discharge from the vault to which I have alluded above, eight recovered; and the details of these eight cases which recovered clearly prove that the watery discharge, however copious, did not appear to have any material effect.

And hence the broad plan of treatment in each case of watery discharge connected with an injury of the head is to be based upon the general symptoms which may exist. These cases must therefore be treated as any other serious injury of the head; the various symptoms, whatever they may be, must, in fact, be dealt with as they present themselves.

Fractures of the Inner Table only of the Skull.

[The *tabula vitrea* was found broken, without corresponding lesion of the external table, in twenty-one cases that were reported during our civil war, amid the vast aggregate of 4022 cases of gunshot fracture of the skull which are borne on the returns (Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., pp. 112, 141, 307); or, in other words, fracture restricted to the inner table was met with once in every one hundred and ninety-two cases of gunshot fracture of the skull which were reported.[1] But, according to Mr. Prescott Hewett's researches, the ratio of its frequency is much greater, for he states that three examples of this variety of cranial fracture were met with in seventy-eight cases of injuries of the head which were examined (post-mortem) at St. George's Hospital during a period of ten years, extending from January, 1841, to January, 1851 (Med. Chirurg. Trans., 2d series, vol. 13, p. 338, London, 1853). The ratio thus obtained, however, is doubtless much above the general average. Still this lesion occurs with sufficient frequency to make it an object of great practical interest to every surgeon, and to require that every large work on surgery should contain an account of it.

Fractures of the inner table only of the skull have proved to be very fatal. The instances reported by Mr. Hewett were all fatal. Of the twenty-one cases reported during our war of the Rebellion, only one recovered.

The specimen is represented in the accompanying woodcut (Fig. 129) which, together with the account of the case, is

Fig. 129.

Fig. 129. Necrosed fragment from the right parietal, showing a depressed fracture of the inner table without lesion of the outer table. Spec. 4194, Sect. I., A. M. M.

taken from the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 147. It consists of a portion of bone from the posterior part of the right parietal near the occipito-parietal suture, measuring an inch and a half in length by almost an inch in breadth. The outer table is unbroken. The inner table presents a fracture depressed about one line. In Fig. 138, a view is given of both the outer and inner surfaces of the specimen. This pensioner was reported, on March 29, 1870, as totally disabled, attacks of vertigo rendering him incapable of any physical exertion. The loss of substance in the skull had been replaced partly by bone, partly by fibrous tissue.

(See also, Dr. W. H. Triplett, Boston Med. and Surg. Journ., 1873, pp. 385–388; also, Am. Journ. Med. Sciences, July, 1873, p. 63.)

Thus, there have been placed on record in this country alone, during the past twenty years, some three and twenty cases of cranial fracture restricted to the inner table. But this lesion was also well known to our predecessors. For instance, Quesnay relates an example of it which occurred

[1] It is not improbable that this lesion was overlooked in some fatal cases of cerebral injury in which the cranial bones were not subjected to post-mortem scrutiny. Dr. Otis also remarks that "doubtless among the cases enumerated as contusions there were those in which the inner table may have been fractured" (ibid., p. 307).

Percivall Pott believed that some of the cases "thought to have been destroyed by concussion, have sunk under this kind of mischief."

Prof. Stromeyer says: "This kind of injury might be observed oftener if we still used the trepan as Pott did, or if one could obtain a reliable diagnosis without opening the cranium."

This lesion, its history and consequences, might best be described by presenting examples and drawings that are in point.

in the practice of M. Soulier of Montpellier. He likewise states that the writings of Valeriola and Arcaeus already contain "sufficient proofs" of "the reality of this kind of fracture." He also refers to a case reported by Tulpius; and to another case mentioned by Borelli (Mem. Roy. Acad. Surg. of France, Syd. Soc. Trans., p. 20, London, 1848).

Paré relates the first undoubted instance of this lesion which we find on record: A cavalier of M. d'Estampe's company received, at the breach of the château of Hedin, a ball from an arquebuse which struck upon his helmet over the parietal bone. The scalp was not wounded, and the helmet but slightly indented. Nevertheless, on the sixth day he died comatose; and Paré, wishing to know the cause of death, opened his skull. The external table was found entire, but the inner table was broken into several fragments, which had penetrated the membranes of the brain. (Œuvres, etc., t. ii., p. 22, Paris, 1840, ed. par J. F. Malgaigne).

Garengeot reports another case (Traité des Operations de Chirurgie, 2d ed., t. iii., pp. 122, 123, Obs. XII., Paris, 1731). This appears to be the first instance on record wherein the existence of this lesion was surmised during life, and, at the same time, the diagnosis was verified by operation.

There are, however, at least four additional cases on record in which the operation of trephining was performed with complete success. They may be found as follows: La Motte (Traité Comp. de Chir., etc., 2mo. ed., t. ii., p. 305, Paris, 1732); Bilguer (Chirurgische Wahrnehmungen, p. 30, Berlin, 1763); S. Cooper (Hennen's Military Surg., pp. 260, 261. Am. ed.); Guthrie (Injuries of the Head affecting the Brain, 4to., pp. 77, 78. London, 1842).

Etiology of fractures restricted to the inner table.—This topic has been thoroughly investigated, experimentally as well as historically, by Dr. Otis (Med. and Surg. Hist. of the War of the Reb., Part I., vol. ii., p. 157). Specimen 1082[70], in Guy's Hospital Museum, is the calvarium of a suicide, who shot himself in the right temple, with a pistol. The ball passed transversely clear through his brain, and struck the inner table of the left os frontis, where it lodged. At the point of impact there is a black mark, but no fissure nor fracture; at the corresponding point outside, however, there is a starred fissured fracture of the external table only.

Mr. Teevan's explanation is doubtless correct. He aptly illustrates this variety of cranial fracture by the familiar instance of the cracking of a thin sheet of ice under pressure. Thus, fissures are often seen to occur on the under surface of the ice when there are no corresponding fissures on the upper surface. In bending a stick across the knee until it parts, the process of breaking always begins on the side opposite to the spot where the knee is applied. Moreover, Dr. Otis "had no difficulty in producing by slight blows with a hammer upon the outer or inner surfaces of calvaria, fissures or stellated fractures of the outer table only or of the inner table only" (*ibid.*, 150). Grima, more than one hundred years ago, correctly held that, in order to produce this variety of cranial fractures, the amount of force of the impinging body must not be great. (Mémoire sur les contre-coups. Couronné en 1766. Prix de l'Acad. Royale de Chirurg., t. iv., p. 257.)

Diagnosis.—This lesion can, not unfrequently, be diagnosticated with considerable certainty prior to operation or to autopsy. Furthermore, Bontecou, having examined the specimens of this lesion belonging to the Army Medical Museum, correctly surmised its presence in a case of gunshot wound of the scalp, and verified

Fig. 130.

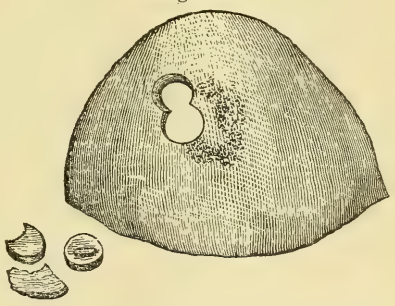


Fig. 130. Segment of a cranium trephined for depressed fracture of the inner table. Spec. 4344, Sect. I., A. M. M.

the diagnosis by applying a trephine. Unhappily an abscess had formed in the brain, suppuration in the diploë also had occurred, and symptoms of pyæmia were already present, and thus the operation, though performed as soon as evidence of compression existed, was too late to save the patient. (Circular No. 6, Nov. 1, 1865.) The instrument was applied twice. A segment of the frontal bone with the two disks and the larger fragment of the inner table, removed at the operation, were sent to the Army Medical Museum, and are represented in the accompanying woodcut, taken from the Med. and Surg. Hist. of the War, Part I., vol. ii., p. 148. A small fragment of the inner table, and another nine by six lines, were found completely detached, and were removed by common dressing forceps.

See also New Sydenham Soc. Year-Book, 1862, p. 269.

La Motte thought that when the inner table alone was broken the lesion might be detected by a peculiarity in the resonance of the skull under percussion, and cites a case illustrating this idea. (Obs. de Chirurg., t. ii., p. 303.) Atthalen of Besançon held the same opinion, and adduced an interesting case which happened in 1746. Dr. Stromeyer also attaches value to this mode of exploration. He says: "By means of percussing with a silver probe, I was enabled in one case, where there was only a barely perceptible fissure in the outer table, to diagnosticate the extent of the inner separation accurately, and after the decease from pyæmia, in this same case, many of the young surgeons had the opportunity of convincing themselves of the correctness of my diagnosis. Any of them who possessed a practised ear could discriminate the sounds when percussing the outer table at the point of the internal fracture, or at other parts on the cranium. At the point of the internal fracture the pitch is somewhat higher. Lanfranc and Ambroise Paré, I find, already knew of this diagnostic expedient." (Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 153.) Percussion of the skull with a silver probe in the way described by Stromeyer can unquestionably be employed with advantage in cases where fracture of the inner table only is suspected.

See also a case recorded by Edwards (Edinburgh Med. Jour., vol. viii., p. 191).

Treatment.—When the symptoms of meningeal irritation or of cerebral compression are persistent and urgent, or when they constantly become more severe, notwithstanding appropriate medication, both general and topical, and especially when there is paralysis, more or less complete, of the side opposite to the fracture, the operation of trephining is clearly indicated. By the timely performance of this operation, examples of this lesion have been successfully treated by Mery, La Motte, Bilguer, Frye, S. Cooper, and Prof. Hughes. In most of the cases belonging to this category recovery is impossible unless the sharp splinters and angles of the inner table are removed by operative procedures. So, too, when this lesion gives rise to intracranial hemorrhage, the trephine should be promptly applied and the coagulum removed.

Fractures of the External Table only of the Skull.

Excepting instances of fracture of the outer wall of the frontal sinus, or of the mastoid and zygomatic processes of the temporal, and of grooving of the outer table of the cranial vault by the sharp angles of shell-fragments, the Army Medical Museum contains no satisfactory specimens of this form of injury, while it contains ten specimens of fracture restricted to the inner table. This circumstance shows that, aside from the exceptions just noted, fractures limited to the external table but very seldom occur. On this point Dr. Otis says: "After a careful examination of the histories of the individual cases, and weighing the evidence impartially, I am sure, I am disinclined to admit that the outer table of the skull is ever fractured in the adult without injury to the inner table, either by projectiles of war or any other external violence, except in the rare instances of blows or the impact of missiles upon the superciliary ridge, or mastoid or zygomatic processes, and possibly the occipital protuberance, or by grooving by a sharp shell-fragment. Pott, Sir Astley Cooper, Sir Benjamin Brodie, Williamson, and others, refer to indentations of the skull or fractures of the outer table as not uncommon; but I believe the view entertained by Velpeau and Samuel Cooper, which I have endeavored to illustrate and corroborate, to be the sound one." (Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., pp. 140, 141.) The writer has no reason to doubt the soundness of this opinion.

Fig. 131.

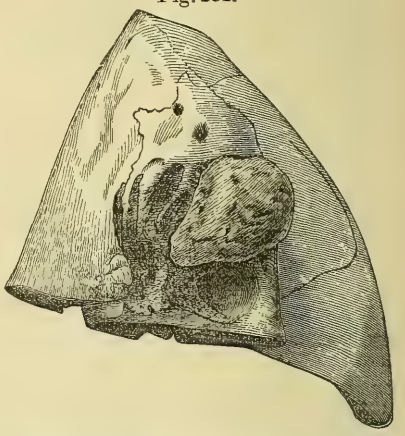


Fig. 131. Segment of skull showing detachment of the mastoid process of the right temporal.—Spec. 183, Sect. I., A. M. M.

A fatal case, the specimen from which is represented in the adjacent woodcut, is given in the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., p. 131.]

Concussion of the Brain.

A man receives a blow on the head, by which he is only stunned for a longer or a shorter period. What is said to have happened? Concussion of the brain.

A man dies instantaneously, or lingers some time perfectly unconscious, after an

injury of the head; there are no marks of external violence. Again, what is said to have happened? Concussion of the brain.

The head is opened, and what is found? In one case, no deviation from the healthy structure; in another, simply great congestion of the cerebral vessels; in another, numerous points of extravasated blood scattered throughout the brain-substance; in another, a bruised appearance in some parts of this organ. In all, the case, in common parlance, is said to have been one of concussion of the brain.

Such are the after-death appearances ascribed by different surgeons to concussion of the brain.

The teaching of the different schools, then, is, that in simple concussion we may either find nothing in the brain to prove that this organ has sustained any injury, the brain-substance and its membranes appearing to be perfect in all their parts, or we may find certain lesions, plainly showing how much the cerebral substance has suffered.

But it behooves us carefully to examine and see how far we are justified nowadays in admitting that these various appearances do really belong to simple concussion of the brain.

And first, as to those cases of instantaneous death ascribed to concussion of the brain, in which no deviation from the healthy structure of the cranial contents is detected.

A century and a half ago was published[1] the first case in which it was clearly and distinctly stated that concussion of the brain may prove instantaneously fatal, without there being, on dissecting the brain, a single trace of injury in any part of the cerebral substance or of its coverings. And this is the celebrated case of Littre, to which reference is always made, even in the present day, to demonstrate that simple concussion of the brain may be followed by instantaneous death; and yet, strange to say, the details of this case afford literally no proof whatever that the man was actually killed by concussion of the brain.

The case stands thus: a malefactor, young and strong, who had been sentenced to be broken on the wheel, determined upon destroying himself. Head foremost, and with his hands behind his back, rushing a distance of fifteen feet across the prison-cell, he dashed his head against the wall, and dropped down dead. On removing the skull-cap, everything was found in its natural condition, and, in fact, perfectly healthy, save that the brain did not nearly fill the cavity of the cranium, as it usually does, and that its substance, as well as that of the cerebellum and of the medulla oblongata, was, both to the touch and to the sight, closer and more compact than usual. And, by way of explaining the sudden death, M. Littre adds, "From the violence of the shock, the brain had shrunk considerably; and, possessing but little elasticity, it could not recover itself, in consequence of which the distribution of the nervous influence throughout the body failed in an instant."

Such is Littre's case, upon which so much reliance has been placed, as affording the strongest proof that simple concussion of the brain may lead to sudden death. But what is there in this case to prove that this malefactor did really die of concussion of the brain? Nothing but the head was examined; and here, even, very little care appears to have been taken to ascertain the exact condition of the brain-substance, and no allusion is made to the cerebro-spinal fluid. And, above all, what is to be said of Littre having, in such a case of sudden death, omitted to examine both the spine and the heart?

Does not the very history in Littre's case at once suggest the idea that this man did not die of concussion of the brain, but of a broken neck? And yet this part was never even thought of. What value should we, in the present day, attach to an examination thus carried on in our own dead-houses? Few of us would, I think, hesitate to say that such an examination proved nothing. And if this be the case, why should we accept from Littre that which we should refuse to accept, under similar circumstances, from any living surgeon?

With its few details and its capital omissions, Littre's case is, then, to me, I must confess, of no value. And such, too, are the conclusions arrived at by M. Fano, who has of late been making some extensive and well-planned researches on the subject of concussion of the brain.

The same may, strangely enough, be said of every other case which has been brought forward to prove the all-important doctrine that concussion without lesion of the brain-substance may lead to instantaneous death. In Sabatier's case,[1] in Boyn's case,[2] in both cases of Mounier,[3] no vestige of injury was found either about the brain or its membranes; and in one and all of these cases there was the same fatal omission,—neither the spine nor the heart was examined. And thus it is with O'Halloran of Limerick.

The perusal of such cases as these would really make it appear as if concussion of the brain had, at one time, been thought to be the only injury by which instantaneous death could be produced.

In all cases of sudden death from injury, there is no doubt that the parts to be examined are the upper portion of the spinal marrow and the heart. Neither is there

[1] Mém. de l'Acad. des Sciences, 1705, p. 54.

[1] Méd. Opérat., t. ii., p. 400.
[2] Thèses de Paris, 1818, No. lv.
[3] Thèses de Paris, 1834, No. cxix., p. 19.

any doubt that, if these parts are not examined, it cannot fairly be said, in such cases, that death was owing to simple concussion of the brain.

A man fell from the height of about forty feet, and died instantaneously. There was an extensive injury of the head; but this was not enough to account for instantaneous death. Further examination proved that there was also a dislocation of the atlas on to the occipital.

The following is a case even more illustrative. Death was not instantaneous; but death was, at first,—and this it is which makes the case so valuable,—thought to be dependent upon simple concussion of the brain. In the year 1843, a man was admitted into the Hôpital St. Antoine, having fallen from a great height on to the pavement. He was collapsed, and in a state of perfect insensibility. There was no paralysis, neither were there any spasms of the muscles. In this state he remained for some hours, and then died. The head was examined. Not a single trace of injury was detected in any of the cranial contents,—everything was perfectly healthy. The case was set down, by all those who had seen it during life and were present at the examination, as a case of death from concussion of the brain. It fortunately happened, however, that Dr. Deville, in going round the wards, heard the result of the examination, and thought it advisable that the spine should be looked to. He proceeded at once to the dead-house, laid open the spinal canal, and there found a most extensive extravasation of blood, completely filling up this canal in its whole length, and extending upwards, even beyond the point where the spinal marrow had been cut across, when the brain was taken out.[1]

Had it not been for Dr. Deville, would not this case have been handed down to us, among the others, as one of death from simple concussion of the brain?

A boy fell from a great height, and was brought into St. George's Hospital with urgent symptoms of concussion, and various other severe injuries, of which he died in a few hours. The head was examined, and, save a little extravasated blood beneath the arachnoid on the surface of both hemispheres, with slight bruising of the brain in two places at its under surface, the brain and its membranes were perfectly healthy. And so, too, was the chest examined, and here was found a rupture of the muscular part of the septum of the ventricles of the heart right up to its serous covering, which alone prevented the blood from being poured into the pericardium. True it is that the pericardium in this case was not filled with blood; but a little more and it would have been so, and a complication, perhaps immediately fatal, superadded to the injury of the brain. And what makes this case still more interesting, as far as concerns our present subject, is, that there was not the slightest indication of any injury having occurred to the chest. No ribs were broken; and thus the rupture of the heart might easily have passed unnoticed, had it not been for the rule, now existing for several years at St. George's Hospital, of examining the various parts of the body in the post-mortem examinations.

Other cases of a similar nature have fallen under my own notice; cases in which death was caused by rupture of the heart from injury, and in which death might have been ascribed to concussion of the brain, had not the heart been examined. It must be borne in mind, too, that instantaneous death, apparently caused by concussion of the brain, may in reality have been the result of fatty degeneration of the heart. Some years back, a man, middle-aged, and of spare habit, whilst endeavoring to lift a heavy clothes-basket on to his head, dropped down dead in Hyde Park. With such a history, the heart was first examined: there was no valvular disease, and no rupture of the heart; but there was extensive fatty degeneration of this organ. And now, supposing that the effort which cost this man his life had been made in endeavoring to save himself in a fall from a height, or to ward off a heavy blow from his head; and supposing too that, under such circumstances, the head only had been examined, and its contents found to be healthy, would not this case have been set down as one of instantaneous death from simple concussion of the brain?

As matters stand at present, then, it still remains to be demonstrated that concussion may prove fatal without leaving a trace of injury in the brain-substance.

This conclusion differs, I know, widely from the teaching of some of the greatest masters in surgery; but I can only say that there is not on record, as far as I have been able to ascertain, a single instance in which the evidence of instantaneous death from simple concussion of the brain will stand the test of anything approaching to a rigid scrutiny.

But of late years several pathologists, whose names stand pre-eminent in connection with cerebral affections, have taught that in fatal concussion appreciable lesions are to be found in the cerebral structures. True it is that these pathologists are not all exactly agreed as to the precise lesion: some—Chassaignac,[1] Nélaton,[2] Sanson[3]—taking merely the millet-seed-sized extravasations of blood disseminated in the substance of the brain, either on its surface or deep in its structure; others—Dr. Bright,[4] Blandin,[5]—taking not only these specks of extravasation, but also the circumscribed patches of contusion. Still, these pathol-

[1] Mém. de la Soc. de Chirurg. de Paris, t. iii., p. 180.

[1] Des Plaies de Tête, p. 104.
[2] Path. Chir., t. ii., p. 575.
[3] Ibid.
[4] Med. Cases, vol. ii., part. i., 1831, p. 408.
[5] Gaz. des Hôp., 1842, No. du 2 juin.

ogists one and all agree in stating that some deviation from the healthy structure is to be found in concussion of the brain when it proves fatal. And M. Fano, one of the latest writers on this subject, comes to this conclusion: "that the symptoms generally attributed to concussion are due, not to the concussion itself, but to contusion of the brain, or to extravasation of blood."[1] And to this I may add, that in every case in which I have seen death occur shortly after, and in consequence of, an injury of the head, I have invariably found ample evidence of the damage done to the cranial contents. Setting aside the cases of large extravasations of blood upon the surface of the brain, the most speedy death has occurred in cases where specks of extravasated blood have been disseminated throughout the cerebral substance, or where blood has been extravasated into the structure of the pons Varolii.

Thus far, rapidly fatal concussion only has been considered; but what appearance does the brain present when the injury has not been of so severe a nature, and where the patient has survived for some short time, or a few hours?

In such cases as these, where death has not taken place until a few hours after the accident, whether there be any actual lesion or not of the brain-substance, there is generally found intense congestion permeating the whole of the cerebral structures; so much so that, upon slicing the brain, innumerable blood-points may be seen everywhere thickly studding both the gray and the white substance. Such were the appearances in the case of Hœvelius, referred to by Morgagni.[2] This extensive congestion is also noticed by Dr. Bright,[3] and by M. Fano, in two of his experiments,[4] where the animals, after being thoroughly stunned for some few minutes, were allowed to come to again, and were then killed by other means within a minute or two after recovery. But the most strongly-marked case of this intense congestion is reported by M. Denonvilliers,[5] to whom the notes of the case were given by Dr. Bayard. And what makes this case still more interesting is, that many of the circumstances connected with it are strangely like those of the celebrated case of Littre. Arrested, and failing in his efforts to get away, the man dashed himself head foremost against a wall, his hands being tied behind his back. He was picked up immediately afterwards perfectly insensible, and died three-quarters of an hour after the injury. As far as the brain itself was concerned, there was not even a speck of extravasation, either on its surface or in its substance, the consistence of which was perfectly natural. But the intense congestion of the vessels of the brain gave rise to a manifest alteration in the color of its structures, its cut surfaces being thickly studded with the minutest blood-points, from whence oozed specks of fluid blood upon gentle pressure. And in this case, too, minute as was the examination in many respects, strangely enough there is no mention made as to any examination of the other parts of the body.

And now, as to the still slighter cases of concussion, where the patient is only stunned for a short time, and then recovers his senses completely. It is usually supposed that here, too, there is only some disturbance in the circulation of the brain, which being but slight, soon passes off.

As may be readily supposed, it happens but very rarely that there is any opportunity of examining the state of the brain in these slight cases of concussion. Sometimes, however, in cases where very slight concussion has existed, death does occur, not from the injury done to the brain, but from some other severe lesion. And in two cases of this kind which I have had an opportunity of examining, and in which symptoms of concussion, of the slightest nature, had altogether passed off within a very short time, I was suprised to find that the brain-substance itself was actually injured. In one case, in which, after a blow on the head, there had been mere giddiness for a few minutes, and then complete recovery, some patches of contusion were found at the base of the brain, marked by minute specks of blood closely clustered together; these patches were, in two or three places, of the size of a shilling, and extended, about a line in depth, into the structure of the brain: there were no disseminated specks of extravasated blood. In the other case, after a fall on the back of the head, the symptoms of concussion soon passed off, and the patient died of some other disease eight days after the accident. In the cavity of the arachnoid, and adhering to its parietal layer, were found thin layers of extravasated blood. The large veins on the surface of the brain were congested; the brain structure itself was much darker than usual from congestion; and in the centrum ovale, close to the right side of the corpus callosum, and extending partly into it, was an extravasation of blood of the size of a nut. This clot still retained the greater part of its coloring matter, but the cerebral structure around it was neither discolored nor softened.

Well-marked traces of injury were found

[1] Mém. de la Soc. de Chir. de Paris, t. iii., p. 199.
[2] Letter 51, art. 10.
[3] Loc. cit.
[4] Loc. cit., exper. 5th and 8th.
[5] Compend. de Chir., t. ii., p. 606.

after death in the brain itself in both these cases. May not such lesions also exist in many so-called slight cases of concussion of the brain which recover? My own impression is, that such appearances exist more frequently than is generally supposed.

Many other morbid appearances have been given to concussion of the brain; but to these I should not allude, were it not that I find them mentioned in some recently-published text-books on surgery. For instance, among the after-death appearances in concussion of the brain, separation of the dura mater from the inner surface of the cranium, when the blow on the head was severe, is said to be a very common condition. As well might we say that in concussion of the brain the bones of the skull are often broken.

Concussion of the brain may be produced in different ways; either directly, from the force being applied to the skull itself; or indirectly, from the shock being transmitted through some other part of the body. What actually happens to the brain in concussion, M. Gama has ingeniously endeavored to demonstrate, by means of a glass matrass filled with a solution of isinglass, approaching as nearly as possible to the consistence of the brain, in which he arranged several threads. And from what he observed in these experiments, M. Gama concludes that a blow upon any part of the vault of the skull, in such a manner as to have its opposite point also in the vault, will lead to a separation of the brain from the skull at these two points. But if the blow bear directly upon the vertex, the separation of the brain will only take place at the point struck; and towards the base of the skull, all that will occur, on account of the flatness and extended surface of this part, will be disseminated "contre-coup." Lastly, in a shock transmitted through the base of the skull, the motion being distributed from within outwards, there will be no separation of the brain at any point of the skull; thus pressed outwards, the cerebral mass, on the contrary, here becomes applied all the more forcibly against the osseous box.[1]

Such are M. Gama's conclusions. The experiment, it is true, is only a rough one; but notwithstanding this, some notion may, I think, be gathered from it, as to what takes place when the brain is shaken.

It is not many years since that surgeons were at great pains to point out the different symptoms which, it was thought, served clearly to distinguish a case of concussion from one of compression. Has further experience proved the correctness of the distinctive characters about which there was at one time so much controversy? I think not. It must be admitted that there is no one symptom, or combination of symptoms, which will enable us to determine positively between concussion and the slighter cases of compression.

And this it is which renders an accurate diagnosis so very difficult, if not altogether impossible, in many cases of injury of the head; the difficulty itself being, no doubt, dependent in many cases upon the complex nature of the injury.

Cases of concussion of the brain are now commonly divided into three broad classes. All classifications of this nature must necessarily be vague and arbitrary; but, nevertheless, some classification of these cases will be found useful both as regards the symptoms and the treatment. In the slighter cases, the effects of the concussion are momentary—loss of sensibility and of muscular power, interference with the circulation; these symptoms soon pass off. The patient comes to again, and proceeds about his business as if nothing had happened, retaining often no knowledge whatever of the accident. In the severest forms of concussion, the patient dropping instantaneously lies senseless and motionless; scarcely breathing, and with no pulse at the wrist. Little or no reaction takes place; and the patient expires within a few minutes, or lingers on for a few hours.

But cases of concussion holding the mean between these two extremes are to us, as practical surgeons, of the greatest interest. At first perfectly insensible, the patient lies motionless and all but pulseless, with a countenance marked by extreme pallor, and a skin quite cold. The breathing, although feeble, is in the great majority of cases performed easily and naturally. The pupils vary very much—contracted, dilated; or one may be contracted, and the other dilated. The urine and the fæces are sometimes voided involuntarily. And in this state the patient may remain for a longer or a shorter period, after which he begins to rally.

No longer altogether insensible, he may be roused by loud calling; pinch the leg, and it will be withdrawn with an expression of peevishness about the countenance; the pulse becomes less frequent and more distinct; color returns to the face, and the skin gradually regains some warmth. And among the earliest signs of amendment must be mentioned vomiting, which is to be looked upon as a good sign; and when it supervenes, sometimes appears to hasten the recovery.

[The writer remembers a case of severe concussion of the brain which occurred during his undergraduate course of professional study. He saw the patient soon after the accident. The insensibility was profound, the "shock" great, and the relaxation of

[1] Des Plaies de Tête, 2e édit., p. 101.

the voluntary muscles complete. His surface was cold and wet, his pulse frequent, small, weak, and irregular, and his respiration slow and sighing. He reacted but slowly, and vomited. The next day, however, the reaction proved violent; he had much fever, with hot skin, bounding pulse, red face, injected eyes, and intense headache. The carotids throbbed violently. The fever was subdued by a calomel purge, by saline drinks, by spare diet, and by cold applied to the head; but the headache proved very persistent. Afterwards his disposition seemed completely changed. He became irritable, morose, and melancholic, whereas previous to the injury he was gay, jovial, and good-tempered.]

And thus matters may go on for a few hours, or for a few days; but as soon as the patient is so far restored as to be able to make any complaint, headache, of a more or less severe character, is almost always found to be present. This pain in the head may exist for a longer or a shorter period, and then pass off; or it may soon be followed by other symptoms, indicative of intracranial inflammation.

Such are the symptoms attributed by most surgeons to concussion of the brain, when it has been of a somewhat severe character. But at the bedside of a patient laboring under such a train of symptoms, after an injury of the head, can we undertake to say that he is suffering from concussion of the brain only? Nay, more, let the symptoms gradually pass off, and let the patient be so far restored as to be able within forty-eight hours to answer questions put to him; let him, in fact, give ample proof of returning intelligence; could we venture, in such a case, upon stating that the case was one of simple concussion? that the prolonged symptoms were not, in a great measure at any rate, due to an extravasation of blood within the membranes, to which the brain had become accustomed?

We may think that the case was one of pure concussion; and at the death of the patient, what do we find? Perhaps, an extensive extravasation of blood within the arachnoid.

An elderly woman having been knocked down and run over by a cab, was admitted into St. George's Hospital, with a severe injury of one of the hands and concussion of the brain; the symptoms of which, however, soon passed off, and she was up and about the ward in a few days. Ultimately, erysipelas made its appearance on the hand, and she died, after having been in the hospital about two months. From first to last the head-symptoms had been attributed solely to concussion of the brain; and yet, at the after-death examination, extensive layers of blood, membrane-like, were found in the cavity of the arachnoid on both sides.

A man aged fifty-three, having fallen down stairs, was admitted into St. George's Hospital, with what was thought to be simply severe concussion of the brain. From this he gradually recovered, and was in due course of time allowed to get up and go about the ward. He died, however, of an attack of erysipelas, two months after the accident. The brain-substance was perfectly healthy, but within the cavity of the arachnoid, on both sides, were the remains of an extensive extravasation of blood, membrane-like, and adhering to the parietal layer of the serous membrane.

I might mention several other cases in which extravasations of blood were found in the cavity of the arachnoid—cases in which the symptoms of concussion had even been altogether transient, and in which death had been brought about by some other cause. Indeed, I cannot help thinking, from all I have seen, that many of the so-called cases of concussion, especially the severe cases in which recovery has taken place at a more or less remote period, have, in truth, been cases of extravasations of blood within the membranes.

There is also many a case recorded by eminent surgeons, and as a matter of course quoted over and over again, in which partial paralysis and loss of memory are said to have taken place after, and to have been due to, concussion of the brain. But here, too, it is much more probable that effects such as these were due not to concussion only, but to some extravasation of blood, or to some local injury done to the brain-substance.

As we have some clearly-marked periods in the symptoms of concussion, so too must we adapt our treatment to these various periods.

In the first period, that of depression, the safest practice is certainly to do as little as possible—to avoid all interference either in the way of bloodletting, on the one hand, or in that of stimulating on the other. Bleeding to any extent, in such a state of depression, may be the cause of most serious mischief, even of death itself. And with regard to stimulants, recourse must be had to them as little as possible; for we cannot be sure that we may not be dealing with a case of extravasation of blood, or of bruised brain; and a period of depression, under such circumstances, would be the safeguard of the patient. Cases of concussion absolutely requiring stimulants are very rarely met with in practice; and even when of a very severe form, all that is necessary in the great majority of cases is, to apply warmth to the surface, and carefully to watch the case; but if it should so happen that the patient is manifestly in danger of sinking from depression of the circulation, then, no doubt, stimulants or cordials must be resorted to.

As is the state of depression, so too will

be the state of reaction: slight depression will be followed by slight reaction; extreme depression by extreme reaction, which will be all the greater if stimulants are used.

And in the stage of reaction, so long as this reaction keeps within due bounds, here again it is better to abstain from all active interference; taking care, however, to exclude all possible sources of excitement; to keep the head and the shoulders well raised, and evaporating lotions constantly applied to the head, which in bad cases must be shaved. Precautionary measures such as these, with a mercurial and saline purge occasionally, and great attention to diet, with perfect rest, will, in a large number of cases of concussion, carry the patient through this period.

When the concussion has been of a somewhat severe character, there is generally no difficulty in getting the patient to submit to the necessary regimen—his own feelings tell him, in fact, that it is absolutely necessary; but in the slighter cases, where all the symptoms soon pass off, feeling as well as he does for the time being, the patient not unfrequently resists all attempts at treatment, and then, within a few days, is laid low, with mischief of a very severe and dangerous nature—so dangerous, indeed, that notwithstanding all care, a few days more bring his life to a close.

In the cases of concussion which die, from some other cause, shortly after an injury, and in which no extravasation of blood or actual injury to the brain-substance is found, there is, it must be recollected, intense congestion of the cerebral vessels, which, in some cases, is so intense as to give a manifestly darker hue to the different substances of the brain. The cases revealing these early appearances are of the utmost value practically; they at once plainly point to the mischief which is likely to arise, and at once give the key to the treatment.

The great danger lies in the tendency which this congestion has of leading to inflammation, and hence the reason why the case is to be so narrowly watched; hence the reason why the state of the pulse and all other symptoms are to be so carefully inquired into, and even the slightest appearances of mischief, as far as possible, guarded against. But intracranial inflammation, taken as a whole, will form the subject of another section.

I cannot, however, dismiss this subject of concussion of the brain without again referring to a point which I consider of the utmost importance in all cases of injuries of the head, of whatever kind. In dealing with scalp-wounds and with fractures of the skull, I pointed out how necessary it was to take into consideration the state of the various viscera, and especially of the kidneys. To scalp-wounds and to fractures must now be added concussion of the brain; the diagnosis, the prognosis, and the treatment of which must be greatly influenced by the condition of the viscera.

[See a valuable case reported by Parke (Brit. Med. Journ., Feb. 19, 1859, p. 145); also one in Med. and Surg. Hist. of War of Rebellion, Part I., vol. ii., p. 44. Consult also Hilton, "Rest and Pain," p. 30. Am. ed.; and Duret, "Etudes Experim. et Cliniques sur les Traumatismes Cerébraux," Paris, 1878.]

Contusion of the Brain.

In dealing with the subject of concussion of the brain, allusion was incidentally made to the bruised appearances often observed about the cerebral substance, where the case had been set down as one of simple concussion.

It is this bruised appearance or contusion of the brain-substance which is now to be brought more directly under notice.

Bruising of the brain-substance presents itself under two different aspects; either spots of extravasated blood are clustered together in well-marked circumscribed patches, or these spots are disseminated throughout various parts of the cerebral mass at the same time. Hence a circumscribed and a diffused form of contusion of the brain.

The former, the circumscribed contusion, much the more common of the two, will be treated of first.

As in other organs, so in the brain, there may be different degrees of contusion. In the slighter cases, the bruised part, of a dark-purplish color, is found upon close examination to be studded with minute specks of extravasated blood, not bigger than pin-points, thickly clustered together; the discoloration gradually lessening from the centre to the circumference, as the specks of blood become more and more scattered. The gray substance alone is affected. Under a gentle stream of water, the patch, if examined within a short time after the injury, retains both its discoloration and its consistence.

In the more severe cases, the central parts of the bruised portion, thoroughly infiltrated with blood, are of a uniform, dark-purplish color, which extends some distance both into the gray and the white substances; imbedded in this part are little clots of blood of the size of peas, and around the circumference and in the deeper parts are specks of extravasation scattered more and more widely until they gradually disappear. The brain-substance—torn, broken up, and shreddy—readily gives way under a gentle stream of water, which,

gradually loosening the clots of blood, carries them away, leaving little pits with irregular and shaggy margins, and thickly studded throughout with pin-point extravasations.

Such are the appearances at an early period after the injury. A few days later,

Fig. 132.

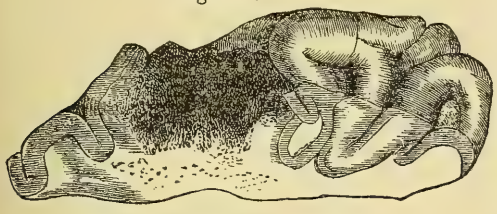


Fig. 132. Contusion of the Brain.

and the bruised part, with its depressed shaggy surface, and sharp irregular borders, looks like an ulcer, and by some surgeons has, in fact, been described as the traumatic ulcer of the brain. At this period, too, the brain-tissue to some distance around the bruise may be of a yellowish color, and each little speck of extravasation may have its own circle of yellow surrounding it.

[In illustration see a case by the writer (Am. Journ. Med. Sciences, January, 1880, pp. 95, 96).]

Slight contusion of the brain may sometimes be found alone; but, for the most part, the various degrees which have just been described coexist in the same brain.

As to the membranes of the brain, in the slighter cases of contusion, the meshes of the pia mater only are more or less filled with small clots of extravasated blood; in the severer cases, both the investing arachnoid and the pia mater are generally torn, and blood is more or less extensively extravasated in the cavity of the arachnoid, as well as in the meshes of the pia mater. Out of sixty-nine cases of more or less severe contusion of the brain, independent of compound fractures, I found blood extravasated into the cavity of the arachnoid in no less than in fifty-two cases. And in thirty-one out of these fifty-two cases, the extravasation was very extensive; so much so, indeed, in several instances, that the quantity is marked thus in the notes of the case: "within the arachnoid large quantities of blood spread out and capping the brain." In eleven cases, no blood was found in the cavity of the arachnoid; but in all these eleven cases, blood was found in the meshes of the pia mater, extending some distance beyond the actual seat of the brain-injury, and in six of them the extravasation was widespread. In the remaining six cases, no blood was found in the arachnoid, and none in the pia mater, except at the actual seat of the injury, and this only in very minute quantities.

Bruising of the brain may occur in every part of this organ; but all parts of the cerebral mass are not equally subject to this form of injury. Some parts of the brain are so frequently bruised that cases of this kind are seldom wanting in the dead-houses of our large hospitals; and other parts, again, are so very rarely injured, that one or two cases only may be met with in a long series of years.

It is but very, very rarely, for instance, that an opportunity occurs of seeing the *medulla oblongata* or the *crura* thus bruised. There is, however, a preparation in the Museum of St. George's Hospital in which several small spots of extravasated blood may be seen scattered deep in the structure of the upper part of the medulla oblongata, as well as in that of the crura of the cerebrum and cerebellum. In this case, too, there were also spots of extravasated blood deep in the pons Varolii; some of these spots were of the size of pin-points, and others, again, as large as a small split-

Fig. 133.

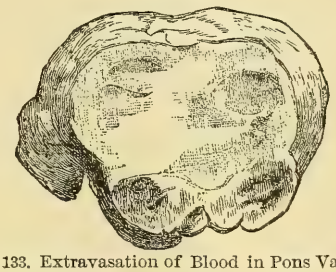


Fig. 133. Extravasation of Blood in Pons Varolii.

pea. No other part of the cerebral mass was bruised or lacerated; but there was an extensive extravasation of blood over the whole of the right hemisphere, and the cerebellum was bathed in blood. The bones of the skull were not in the least injured.

Of the *pons Varolii* only four other cases of contusion have been met with at St. George's Hospital within the space of sixteen years. And the cases of this kind on record are also but few in number.

In a case mentioned by M. Boinet,[1] the centre of the pons Varolii was bruised, and this was the only injury existing about the brain-substance. And in another case by M. Fano,[2] the structure of the pons Varolii was studded with several small extravasations of blood about the size of a split-pea; the anterior lobes of the brain were exten-

[1] Arch. Gén de Méd., 1857, p. 50.
[2] Rech. sur la Cont. du Cerv., obs. xii., p. 25.

sively bruised and torn, but the skull was not broken.

One point especially must be borne in mind in connection with these traumatic extravasations both in the medulla and in the pons. The surface of these structures may be perfectly healthy, and yet well-marked spots of extravasation may exist deep in the substance, and that, too, even when there has been no bruising of any other part of the cerebral mass. Contusions such as these may then, it is evident, easily escape notice, unless very carefully sought after.

In the *cerebellum*, bruising and laceration occur more frequently than in the structures which have just been examined; and in this organ these injuries are, for the most part, to be found at its under surface. The spots of ecchymosis are generally small and superficially situated, and confined, moreover, to one lobe at a time. Sometimes, however, extravasations take place in the deeper parts, and then there may be either one largish single spot, as in a preparation in the Museum of St. George's Hospital, in which an extravasation of the size of a filbert is imbedded deep in the structure; or there may be, as in Blandin's case,[1] a large number of minute spots scattered in the substance of this organ. In the twelve cases of bruising and laceration of the cerebellum, notes of which I have by me, other parts of the brain were at the same time extensively bruised, and the skull was broken. The nature of the accident was not always very severe, and this must be borne in mind. In several instances I found that the cerebellum was thus injured by the patient having fallen in the street while drunk.

In the *cerebrum* itself it will be found that even here some parts of this organ are much more commonly affected than others. As in the cerebellum, so in the cerebrum, the under part is very much more frequently bruised than any other. Sometimes limited to a few patches of contusion, the injury much more commonly extends over the whole surface of a lobe, and oftentimes of two lobes at once. Both the gray and the white substance may be extensively involved; and, in depth, I have known the whole structure to be so broken up and destroyed that the lateral ventricle has been laid open. A man fell from a height of about eight feet, the result of which was extensive bruising and laceration of the under surface of both anterior lobes; freely laying open, on the right side, the lateral ventricle, into which the finger was readily passed. And, in another case, a man fell from a tree a distance of fourteen feet, and so injured the under surface of the anterior lobe on the right side that the lateral ventricle was here freely laid open.

But in the cerebrum, too, the deeper parts may every now and then be found bruised; and the bruise, thus deeply situated, may either exist alone, or it may coexist with an injury of the surface, although independent, and far away from it. And every part of the cerebrum may be thus injured; and being, perchance, very limited, the injury may here also easily escape notice. Thus, in one case, the septum lucidum was lacerated in nearly its whole length; it appeared to be bruised, and had several spots of ecchymosis in various parts of the remaining portion of the septum, and in the fornix at the back part. No other laceration was detected in any other part of the cerebral mass; but several patches of extravasated blood existed in the cavity of the arachnoid, and in the meshes of the pia mater. In another case, a minute extravasation of blood was found in the edge of the fornix, another on its under surface, and several specks also on the surface of the thalamus; the only other traces of injury were patches of blood in the sub-arachnoid tissue, corresponding to the posterior lobes of the cerebrum, and to the posterior part of the cerebellum. In a third case, the extravasation of blood in the brain was of the size of a nut in the right centrum ovale, close to the side of the corpus callosum; no other laceration could be detected in any other part of the cerebral mass, but several thin layers of blood were found extravasated in the cavity of the arachnoid. In a fourth case, the corpus callosum and the velum interpositum were slightly bruised, in connection with superficial bruising of the surface of the brain; and in a fifth case, several minute specks of extravasated blood were discovered in the fornix and septum lucidum, in connection with other and severe bruises of various parts of the brain. And in connection with this subject it may be mentioned that a laceration of the floor of the lateral ventricle, even when very, very slight, may give rise to an extensive extravasation of blood into this cavity, should it so happen that the injury corresponds to the situation of one of the large veins in this region. In a preparation in the Museum of St. George's Hospital, there is a slight laceration of the septum lucidum, as well as of the floor of the left lateral ventricle, where a large vein was laid open, and the ventricle was full of blood.

Thus much as to circumscribed contusion of the brain. In the general or diffused contusion of this organ, the spots of extravasated blood, instead of being clustered together in one part, are disseminated throughout the brain, on the surface as

[1] Gaz. des Hôpitaux, 2 juin, 1842.

well as in the deeper parts, or it may be in the deeper parts only.

Circumscribed contusion of the brain we already know to be of very frequent occurrence. Diffused contusion of this organ, we shall find, on the other hand, is but very rarely met with. Circumscribed contusion is for the most part easily detected, and at once clearly recognized. Diffused contusion is sometimes difficult of detection, and, without careful examination, may readily pass unnoticed.

Diffused contusion of the brain is characterized by specks of extravasated blood disseminated throughout the brain-substance. These minute extravasations vary from the size of the smallest pin-points to that of a split-pea. In the latter form, the extravasation could hardly escape detection; but in the former, the minute specks might, in slicing the brain, be easily mistaken for the cut surface of cerebral vessels. A little care, however, will enable us to distinguish between the two. In the case of cut vessels, the specks can be easily wiped away, and then, by gently squeezing the brain, other specks of blood may be made to appear. The miliary extravasations cannot thus be wiped away; but, picked out with the point of a knife, they leave little holes, in which the concrete drop of blood was imbedded. The brain-substance around these minute holes may still retain its natural color; or, some days after the accident, it may be of a yellowish color, such as is so frequently noticed under similar circumstances in bruises of other parts. Thus, in Blandin's case, already alluded to, which terminated fatally some eight or ten days after the injury, each little spot of extravasated blood was found encircled by cerebral substance of a yellowish tinge, varying from a violet color to a greenish-yellow.

The specks of extravasated blood characterizing diffused contusion of the brain may, in any case, be numerous, or they may be few; sometimes so few, indeed, that one speck here and there is all that can be found. And this points out at once what extreme care must sometimes be required in examining cases of this kind; and it also points out how readily a lesion of this delicate nature may escape notice in a rough examination—such, for instance, as used formerly to be carried on in our dead-houses.

One of the best-marked cases of diffused contusion is that described by M. Chassaignac in the Mém. de la Soc. de Chir. de Paris, vol. iii., p. 208. Another equally well-marked case is that of Blandin above alluded to. In both these cases, the miliary extravasations were very numerous and widely scattered; but in a case which occurred at St. George's Hospital in the year 1854, the spots, although well marked, were very few. In this case, three very small spots of extravasated blood were found in the substance of the anterior lobe of the left hemisphere; another small spot in the fornix, and another in the right lobe of the cerebellum. And these were all; some minute extravasations existed also in the cavity of the arachnoid, and in the meshes of the pia mater; but there was no fracture of the skull.

These minute traumatic extravasations of blood scattered throughout the brain-substance have of late years been looked upon, as I have already said, by some surgeons of eminence, as especially belonging to concussion of the brain; but such appearances cannot properly be assigned to concussion. Miliary extravasations of blood, whether clustered together in one patch, or disseminated in various parts, belong, one and all, to contusion of the brain. The morbid appearances, although apparently so dissimilar, are essentially of the same character. The contusion, limited in one instance, is general in the other.

Bruising of the brain-substance may take place at the spot where the skull was struck; or the bruise may be in a part of the brain far away from the original seat of the injury. The one, then, is a direct contusion, the other a contusion by contre-coup, of the brain-substance.

And as an illustration of what takes place in contusion of the brain, reference may be made to experiments such as M. Gama's, in which may be seen the effects produced upon the spot where the blow bears directly, as well as the effects which occur in the parts diametrically opposite.[1]

Contusion of the brain is, however, rarely limited to the region where the blow was struck, except in cases where the bone has been driven down. In fissure of the skull it happens much more frequently that the bruised part of the brain is far away, and directly opposite to the seat of the blow. In severe injuries, both kinds of contusion, direct and by contre-coup, are sometimes found in the same brain.

Bruising of the brain occurs, then, in some parts of this organ much more frequently than it does in others. The upper part of the brain is seldom bruised. Out of thirty-six cases of bruised brain accompanying fractures extending from various parts of the vault into the base of the skull, the upper surface of the hemispheres was bruised in five cases only. The base of the brain is the part most frequently injured; but even here the various regions differ widely in this respect. The posterior lobes are rarely injured, the anterior ones very frequently, and the middle lobes the most

[1] Des Plaies de Tête, 2e édit., p. 101.

frequently of all. Out of the thirty-six cases just alluded to, the posterior lobes were bruised in four instances only, the anterior lobes in eighteen, and the middle lobes in no less than twenty-five. In twelve of these cases, the anterior and the middle lobes were bruised at one and the same time, the injury having been most severe.

And now, bearing in mind what was stated as to the frequency of the fractures of the various regions of the base of the skull, the middle part of the base of the brain, like the middle fossa of the skull, will be found to be the most frequently injured.

The analysis given by M. Fano as to the frequency of the contusion of the various parts of the brain differs from that which I have just mentioned. M. Fano[1] found the anterior lobes more frequently bruised than any other part of the brain; but then the number of cases thus analyzed was very small—only eight. Had M. Fano's numbers been larger, the results would, I think, have been pretty much the same in both analyses.

Why is it that the middle and the anterior lobes are so much more frequently bruised than the posterior ones? A glance at the anatomical relations of these various parts of the base of the brain affords, to a certain extent, a satisfactory explanation. The posterior lobes lie upon a soft cushion, the tentorium cerebelli; but the anterior and middle lobes are in contact with irregular and angular projections of bone, which, although rounded off to a certain extent, and smoothed down by the dura mater, are still both sharp and numerous.

This subject has been made one of importance by M. Fano,[2] who after carefully pointing out the various pieces of sharp bone in these parts, expresses great surprise that no allusion should ever have been made to them in connection with contusion of the brain by contre-coup. The following, however, are Sir Benjamin Brodie's own words, written some thirty years ago now: "The great irregularities which exist on the inner surface of the basis of the cranium sufficiently explain wherefore the inferior is more liable to be ruptured than the superior surface of the brain."[3] And nothing could be more explicit.

Are there any means of recognizing the cases in which the brain has been thus bruised and lacerated?

Dupuytren,[4] to whom we owe much of what is known of contusion of the brain, was decidedly of opinion that we had no means of recognizing the injury. This celebrated surgeon distinctly taught that contusion of the brain does not reveal itself by any symptoms until a few days after the accident; that is, until the period—four or five days after the injury—at which inflammatory symptoms begin to show themselves.

And such, too, was the opinion first entertained by Sanson. "It is not until after four or five days that the signs of contusion become manifest; and then these signs are similar to those of inflammation of the brain."[1] But in after-years, laying aside this opinion altogether, Sanson professed that contusion of the brain has its own characteristic signs, which, appearing at the very time of the accident, clearly reveal the nature of the injury.[2] And the symptoms by which Sanson thought that he could thus at once recognize contusion of the brain are, in the severer cases, tonic spasms of the limbs; intense restlessness, with constant rolling and tossing about in bed; unconsciousness, more or less complete; drowsiness, without any stertorous breathing. And in the slightest cases, simply contraction of one pupil, or of one eyelid; spasmodic movements about some one muscle or another of the face or lips, giving rise to a difficulty of pronunciation.

Such was Sanson's teaching in his latter years; and such, for the most part, is the teaching of the present school of French surgery, wherein it is broadly and distinctly laid down that, as a general rule, contusion of the brain does at the very outset give rise to a train of symptoms by which the injury may be recognized, if the various symptoms be only weighed with due care.

But after careful and patient watching of many a case of severe injury of the head, I must confess that I do not think we are really in a position thus clearly to recognize a case of contused brain.

There is no doubt that cases of contusion of the brain are frequently met with, in which tonic spasms of the muscles and extreme restlessness, with constant tossing and rolling about, are the principal symptoms; but there is no doubt also, that as frequently, if not more frequently, cases of severe contusion of the brain are met with, in which the symptoms either never make their appearance until some days after the accident, or are altogether wanting.

I have, I think, fairly tested Sanson's doctrine, both in the wards and in the dead-house; and, from all I have seen, I have been led to conclude, that contusion of the brain does not give rise to any symp-

[1] Thèse sur la Cont. du Cerv., p. 44.
[2] Loc. cit., p. 44.
[3] Med.-Chir. Trans., xiv., p. 334.
[4] Clin. Chir., t. ii., p. 490.

[1] Dict. de Méd. et de Chir. Prat., t. viii., p. 452.
[2] Boinet, Arch. Gén. de Méd., mai, 1837, p. 39.

toms immediately after the injury—that it has, in fact, no characteristic signs of its own.

M. Fano, to whose valuable thesis I have already referred, has come to the same conclusion. And in this thesis[1] will be found an able analysis of the memoir which M. Boinet[2] wrote for the express purpose of maintaining and proving the correctness of Sanson's views. In summing up the cases brought forward in this memoir, M. Fano proves that seven only out of the nineteen were really of any value for M. Boinet's purpose. In these seven cases, the so-called characteristic symptoms coexisted with contusion of the brain; but then, in these seven cases, there were also, about the head, other lesions of a serious nature, which may perhaps have had just as much to do with the symptoms as the contusion of the brain.

Why should not a thin stratum of blood widely spread over the brain—why should not laceration of the investing membranes of the brain—have something to do with the tonic spasm and the restlessness? In severe bruising of the brain, these lesions are very common; so common, that, as I have already mentioned, out of sixty-nine cases of this kind, blood was found extravasated in no less than in sixty-three. And, as a possible cause of the symptoms, there is also the intense congestion which, it is known, takes place in the brain-substance almost immediately after it has been bruised.

But why is it that such symptoms exist in some injuries of this kind, and not in others? To this the only answer that can be given is, that this is one of those questions which cannot be fairly met in the present state of our knowledge.

There are, then, no characteristic signs by which contusion of the brain can be clearly recognized; but, nevertheless, it may be predicted that the brain has been bruised, whenever the symptoms are severe after an injury of the head. At least, certain it is, that in severe injuries of this kind, and especially after diffused blows—the most common form of accident in civil hospitals—certain it is that in the vast majority of these cases the brain will be found bruised. Nay, more; if we bear in mind which parts of the brain are the most frequently thus injured, we may even go so far as to say that it is the under surface of the middle or anterior lobes which is bruised.

Contusion of the brain must be considered as a most dangerous injury; but is it always fatal?

One sees patients recover after an injury of the head, in whom it was more than probable, from the nature of the accident and the severity of the symptoms, that the brain was bruised; but of this, unless in very rare circumstances, no positive evidence can be obtained.

When recovery does take place, the contusion is repaired in the same manner as apoplectic hemorrhage into the brain. In the slightest cases, all traces of the contusion may have passed away, if death occurs independently of, and some time after, the accident; or the only trace left may be a hardened cicatrix, with, perhaps, some coloring matter in the centre. But clearer evidences of a former contusion of the brain are occasionally met with; and here the appearances, as might have been expected, are precisely similar to those observed in old apoplectic effusions. If on the surface of the brain, the portion which had been bruised may present some of the well-known appearances so accurately described by Rokitansky,[1] in his "peripheral" form of apoplexy. Of this Mr. Henry Lee's case affords a well-marked illustration.

Since the above was published, I have had an opportunity of examining the brain of a man who, twenty years before his death, had been under my care for very severe injury of the head. The convolutions of the anterior part of both hemispheres of the brain were extensively excavated, and here the arachnoid and pia mater were carried evenly over both depressions, so that a space was enclosed beneath them, which was filled by loose areolar tissue and serum. In the right hemisphere, the mouth of the excavation was nearly circular, about an inch and a half in diameter, and so placed, that the inferior margin lay close to the base of the brain, whilst the inner one was close to the median fissure. The depth of the excavation was about an inch, and the convolutions around its edge were natural. The cavity commenced for the most part abruptly, but one or two convolutions could be traced in a stunted condition down the walls, which had an even surface, and were loosely coated with areolar tissue. In the corresponding part of the left hemisphere, there was also an excavation, similar in all respects, save that it was only about half the size of that in the right hemisphere. The cerebral tissue, in the neighborhood of these cavities, and forming their walls, had a perfectly healthy appearance. There were no remains of blood extravasated in the cavity of the arachnoid; the other parts of the brain were perfectly healthy, and so, too, was the brain-case; no traces of fracture, no sign of injury to the bones. The patient died of aneurism of the subclavian artery, at the age of forty-eight, but twenty years before his death he had been admitted into St. George's Hospital, when I was house-surgeon, with several other men, all of whom had fallen a great height in consequence of the giving way of some scaffolding. At the time of his admission, he was suffering from several severe injuries; and especially of the head, marked

[1] Op. cit., p. 23.
[2] Loc. cit.
[3] Path. Anat., vol. iii., p. 393.

[1] Path. Anat., vol. iii., p. 394.

by the symptoms of so-called concussion of the brain, but there was no sign of fracture of any part of the skull. For several days, he struggled between life and death, in a state of perfect unconsciousness, followed by a violent delirium, which ultimately, however, subsided, and in a few weeks he was so far well, that he was able to leave the hospital. After a while, he resumed his occupation, that of a house decorator, and for years he worked for one of the best firms in London, and was known as one of their ablest workmen. His intellect was as clear as it had ever been, and when I accidentally met him, from time to time, he always said that he did not suffer more from headaches than other people.

The specimen is in the Museum of St. George's Hospital, and from it the annexed woodcut was taken.

Fig. 134.

Fig. 134. Depression of Brain.

In dealing with concussion of the brain, I have already remarked that it is more than probable that some of the cases so often quoted as instances of slight paralysis, or of loss of memory after concussion, were in reality cases in which the brain had been bruised. Of this I think that there can be no longer any doubt.

That which is most to be feared, when the brain has been bruised, is inflammation of the surrounding substance; and this it is which must be guarded against as much as possible. The great tendency in injuries of this kind is, that the brain and its membranes should become inflamed; and as this inflammation is apt to creep on most insidiously, every injury of the head in which the symptoms have been marked ought to be most carefully watched, and treated accordingly. Our watching ought to be carried on for days, for oftentimes the symptoms of traumatic inflammation suddenly show themselves, and without any manifest cause, when all was apparently going on well. The fourth or fifth day was stated by Dupuytren and by Sanson to be the period at which the febrile symptoms were likely to make their appearance. This, then, is the period when we ought to be most watchful for even the slightest sign of inflammation of the brain and its membranes; but of this I intend to treat at length in another section.

[Wounds of the Brain.

These lesions are not characterized by any special symptoms apart from those of concussion or compression. Such accidents are always of a very grave nature, and, as a rule, fatal. Wounds of the brain heal readily when secondary inflammation does not take place; but the prognosis must always be unfavorable, because of the great risk of that occurrence. Wounds of the anterior and upper portions of the hemispheres are least dangerous; wounds of the posterior portion of the hemispheres and of the base are most so. When brain-substance is pressed out of the skull in cases of fractured base, a grave injury is always inflicted, for the crushing force must have been severe to have produced such a complication. Some remarkable instances of recovery after the escape of brain-substance are, however, recorded; and several have passed under my own observation, but they are too rare to be dwelt upon as offering any hope in bad cases (Bryant). In treating wounds of the brain the principal indications are—1. The removal of foreign bodies; 2. The employment of antiseptic dressings; and, 3. The prevention of secondary inflammation by enjoining rest and enforcing the antiphlogistic regimen, and by the local application of cold.

Wounds of the dura mater are probably as dangerous as wounds of the brain, for inflammation of the meninges is readily kindled by such injuries. It is for this reason that compound fractures of the skull are so serious; that simple fractures attended with comminution of the inner table are so often fatal; and that punctured fractures have so dangerous a tendency; for in all these cases the dura mater is not only torn, but irritated by the projecting spiculæ of bone with each pulsation of the brain, and secondary inflammation of the meninges results, which, as a rule, spreads rapidly over the brain and causes death (Bryant). In treating such cases the causal indication is the removal of the depressed bone and the projecting spiculæ from the dura mater by the operation of trephining, elevating the depressed bone, and extracting the fractured splinters. Antiseptic dressings should be applied to the wound, the antiphlogistic regimen with rest should be enforced, and the ice-bag should also be employed locally if the other measures do not suffice. The operation should be performed when possible before the secondary inflammation has supervened.

Foreign Bodies Lodged in the Brain.

"The foreign body never becomes a harmless tenant, its presence always furnishing a potential source of mischief, and

recovery can only be held to take place in a limited sense, for notwithstanding the absence of symptoms, speedy dissolution may ensue with little or no preliminary warning." Therefore, every reasonable effort should be made to extract foreign bodies when lodged in the brain. There can be no doubt that all extraneous substances within view or reach, in cases of penetrating wounds of the cranium, should be removed by the surgeon; but before he commences any unguided search for them in the fragile structure of the brain, he ought seriously to consider the injury which he may inflict. He should also remember that patients have died under the surgeon's hand while exploring the brain to find foreign bodies; and, furthermore, that life has been preserved in many instances where they have not been looked after, or their presence suspected.

When the track of a leaden ball or any other body is to be traced in the brain, an elastic bougie may well be employed for the purpose, as recommended by the elder Larrey. He asserts that it can be done in this way with safety and with effect. He informs us that he traced a ball which entered the frontal bone of a soldier during the insurrection at Cairo, by means of an elastic bougie, from the orifice to the occipital suture, in the direct course of the longitudinal sinus; and by a corresponding measurement externally he was enabled to successfully apply the crown of a large trephine over it, and to extract it, together with some pus mixed with blood. The man recovered. In the absence of an elastic bougie, a female catheter or the porcelain-tipped probe of Nélaton may be employed. These instruments should be allowed to sink into the wound by their own weight; they should not be pushed forcibly onward. It is better to temporize than to probe violently an injured brain. Great care should be taken that the exploring instrument is not thrust out of the track of the foreign body. Moreover, when the site of the missile cannot be ascertained by one or at most two explorations of the wound, further attempts to find it by probing should not be allowed.

No fresh aperture should be made in the skull for the extraction of foreign bodies lodged in the brain, unless, 1. The place of lodgment has been certainly ascertained, and, 2. The place of lodgment is in the cortex of the brain, or not very far beneath it. When the position of the foreign body can be clearly located, and when its removal is not attended with too great destruction of brain-tissue, it certainly should be attempted.

For instances in point, the reader is referred to the St. Louis Med. and Surg. Jour., March, 1870; Am. Jour. Med. Sciences, Oct., 1871, p. 385; Am. Jour. Med. Sciences, January, 1872, p. 120.

When blows are struck on the head with knives, forks, scissors, or other sharp-pointed instruments, sometimes pieces are broken off and remain sticking in the brain, as happened in cases reported by Baron Dupuytren, by Dr. Moritz, and by Dr. Rentz. In all such cases the foreign body should be promptly removed, the aperture in the skull being enlarged for the purpose by the application of a trephine whenever necessary.

Cerebral abscess is a frequent cause of death in cases where foreign bodies remain lodged in the brain. It was present in at least fifty-three fatal cases where post-mortem examinations were made. Apoplexy, also, is a cause of death in these injuries, but much less frequently than abscess. In some cases of apparent recovery where foreign bodies remained in the brain, the patients did well until some cerebral excitement was experienced; five cases are recorded where death took place suddenly after excessive drinking; in one case during the excitement of a game of cards; in another case after a slight injury of the head. (Monthly Abstract of Med. Science, Sept., 1879, p. 412.)

In one case, where a musket-ball had penetrated the brain and was not extracted, which remained under the writer's observation upwards of a year, there was acute suffering from pains darting across the base of the brain from the right temple to the scar of the wound behind the left ear. There was also vertigo, but no paralysis existed, and the functions of the body were generally well performed. The cicatrix, though tender, was firm. This man was allowed, at his own request, to serve in the capacity of nurse; but, in two weeks' time, he was relieved from this task, as the pain and vertigo were unduly increased, and he was becoming pale and emaciated. In such cases all the surgeon can do is to obviate the tendency to death, by enjoining on the patient a quiet and regular mode of life, and by removing intercurrent cerebral congestions by the administration of cathartics, by dry-cupping the nape of neck and temples, and by the application of cold to the head, from time to time as the symptoms indicate.]

Protrusion of the Brain-substance.

Protrusion of the brain may be the immediate consequence of, or it may come on some time after, the accident.

Contused and lacerated portions of brain-substance may be driven through a fracture of any part of the skull; such protrusions almost always, however, occur in some part of the vault, in connection with a com-

pound fracture and laceration of the cerebral membranes. And however dangerous such an injury may be, the records of surgery contain a large number of cases in which, after the escape of more or less cerebral matter, the patient has recovered, and that without any apparent detriment, either physical or intellectual. Opinions, however, differ as to the chances of recovery in wounds of the brain in different regions of the vault of the skull. On the one hand, Sir Benjamin Brodie[1] states that he had not been able to discover, among all the works which he had consulted, a single instance of recovery from a wound of the posterior lobes of the cerebrum; and in the great majority of cases in which a cure had taken place, the injury was confined to the frontal bone, and to that part of the brain which is covered and defended by it. On the other hand, Mr. Guthrie's[2] experience led him to believe that an injury of apparently equal extent is more dangerous on the forehead than on the side or middle of the head, and much less so on the back than on the side.

But it occasionally, although very rarely, happens that brain-substance is forced through a fracture of the base of the skull, in direct communication with the ear or with the nose, or it might be with the pharynx. In such cases, the injury done to the brain-case and its contents must, as a matter of course, be most severe, and with very rare exceptions, necessarily always fatal.

Of brain-matter forced through the meatus externus, I saw a case at St. George's Hospital in October, 1856. The accident was caused by a fall head foremost from a great height; and with profuse bleeding from the left ear were mixed minute portions of brain-substance, and two or three larger pieces, as big as peas, of the white substance of the brain were lying in the meatus externus. Two cases of the same kind are on record; one in the Journ. de Méd. et de Chir., 1779, vol. lii., p. 454; and the other in the Annales de Chir., 1843, vol. viii., p. 229.

Of brain-matter forced through the nostrils, a case is recorded in the Compend. de Chir., vol. ii., p. 595; and another in the Bull. de la Soc. Anat. de Paris, 1837, p. 228.

Injuries such as these are, I said, necessarily almost always fatal. Occasionally, however, recovery does take place. One such case I recollect seeing at St. Bartholomew's Hospital, under the care of Mr. Stanley. There had been a fall from a height of twenty feet; and, with some clots of blood, a portion of the brain of the size of a hazel-nut escaped through the right nostril. The injury was followed by severe inflammatory symptoms; but notwithstanding all this, the man, aged forty, was discharged from the hospital, cured, eighteen weeks afterwards. The case is published in the Medical Gazette.[1] And another case of recovery after an equally severe injury has lately been recorded in the Amer. Journ. of Med. Sc., April, 1859, p. 354. In this case, the patient, aged thirty, plumped from a great height on to the crown of his head; there was copious bleeding from the right ear, and with it a small quantity of brain-matter. On the following day, a fluid of watery character was flowing from the ear; and in the meatus were several particles which, carefully examined, proved to be true brain-matter. The man returned to his duty five weeks after the accident.

I have never seen a portion of the brain forced into the pharynx, but I have found the contents of the pharynx within the skull, into which they had passed through a widely-separated fracture at the base.

Thus far those cases only have been considered in which protrusion of the brain occurs at the time of the accident. In all these cases it is the broken-up brain-matter which is driven out of the skull; about this there is no doubt.

But protrusions at times occur a longer or a shorter period after the accident, which have been described, more especially by English surgeons, under the term of hernia cerebri; and under this general head have been included protrusions of divers natures, and some even having nothing of brain-matter in them.

Some protrusions are said to have arisen simply from blood extravasated on the outer surface of the dura mater. Described as *tumeurs hématiques* by M. Velpeau, such protrusions have nothing to do with the brain-substance; the dura mater is not even broken through. An outgrowth of this nature might present all the appearances of one form, at any rate, of hernia cerebri; and most difficult would it be, during life, to decide as to the precise connections of the tumor. But cases such as these must be very rare.

In hernia cerebri—such, I mean, as it is described by English surgeons—the protruded substance appears to have varied somewhat in its nature; but, whatever may have been the actual appearance of the tumor itself, the dura mater was at any rate torn through, and the protruded substance was more or less intimately connected with the brain. In some cases, the protrusion is described as having been chiefly composed of blood extravasated un-

[1] Med.-Chir. Trans., xiv., 421.
[2] Injuries of the Head, p. 2.

[1] New ser., vol. iii., 1846, p. 77.

der the pia mater, between it and the surface of the brain, or in its most superficial parts. In other cases, the appearance of the protruded mass was that of true brain-substance, looking exactly like the structure of the brain, with which it was continuous. And in other cases, again, the tumor is represented as an over-abundant granulation from the brain, the injury of which it was destined to repair. Indeed, some surgeons believe that this is the only form in which hernia cerebri shows itself: not then a protrusion of brain-matter; not a hernia cerebri; but simply a growth from its over-luxuriant granulation.

Personally, I have had but very few opportunities of examining the substance driven out of the skull in hernia cerebri, as but two cases of this affection have occurred in the wards of St. George's Hospital during several years past.

In both cases, the protruded substance certainly presented all the outward appearances of brain-matter; and in the last one, which occurred in the year 1855, bits taken away from different parts of the surface of the protrusion were, at various periods, examined microscopically: blood-cells, exudation-corpuscles, and many nerve-tubules were detected in every portion thus submitted to the glass; and this, at any rate, leaves no doubt as to the protrusion being, in some cases of hernia cerebri, formed, in part, of true brain-matter. I may add that, in this case, the first escape of brain-matter took place through a rent in the dura mater, immediately after the removal of a depressed piece of bone. No further escape of brain-matter occurred until after the fourth day, when the protrusion began to show itself; from this period it went on gradually increasing, and ultimately formed a large foul mass, portions of which sloughed off daily. Within a few days of the patient's death, however, the protrusion became much less, and the wound put on a healthier aspect. The immediate cause of death was purulent infection.

The destruction of brain-matter in some cases of hernia cerebri is sometimes very great. In a case published by M. Bouchacourt,[1] the destruction was so great that the lateral ventricle was laid open, and, for days, limpid fluid issued through the wound.

Is it true that the size of the hole in the bone has much influence in causing hernia cerebri? It has been generally taught, and Mr. Guthrie has stated, that protrusion of the brain "rarely or never takes place, when a considerable portion of the skull has been lost or removed; the brain being able to expand to such an extent as the inflammatory impulse from within may render necessary."[2]

But facts prove that hernia cerebri may, and does, take place even when large portions of bone have been lost. In the case of M. Bouchacourt,[1] the hernia cerebri showed itself after a piece of the frontal bone of the size of the palm of the hand had come away. I have also seen a hernia cerebri occur after a considerable loss of the frontal bone—the lower part of the perpendicular portion of the right side, and the whole of the correspondng orbitar plate. And a case occurred not long ago, at the Lock Hospital, in which hernia cerebri took place after separation of nearly the whole of the frontal bone.

There is no doubt that hernia cerebri is mainly due to inflammation of the brain, and to the effusion of serum and pus, which so commonly attends these cases. Where the brain protrudes, the cerebral substance around is for the most part congested, swollen, œdematous, and soft; yellow softening may extend more or less into the surrounding parts, and a great portion of the tissue may be broken down. Abscesses of various sizes, sometimes very large, are not unfrequently found in the hemisphere involved, and large effusions of various kinds fill the ventricles. And, in addition to all this, there is generally extensive effusion of lymph and pus, both in the cavity of the arachnoid and in the subarachnoid tissues.

Hernia cerebri may present itself in any part of the skull. It occurs, however, by far more frequently about the vault of the skull, and especially the frontal and parietal regions; but these localities are, it must be remembered, precisely those in which injuries with loss of bone occur also most frequently. Hernia cerebri is rarely found in fractures of the base, and for this reason, that in the great majority of the instances the injury to the bone is here a simple fissure, and without any laceration of the dura mater. Whenever a fracture of the base is accompanied by a large enough separation between the fragments, or by loss of bony substance, as well as by a laceration of the dura mater, then there is no doubt that hernia cerebri may arise. Such fractures are, however, very rare.

One of the most striking cases of hernia cerebri at the base of the skull was under the care of Mr. Cæsar Hawkins, a few years ago, at St. George's Hospital. The patient, a boy, aged eleven, accidentally shot himself with a horse-pistol loaded with a bullet, which smashed the right malar bone below the orbit, and then lodged in the head. After he had recovered from the first effects of the accident, he went on without any marked cerebral symptoms for seven days, when he became restless, and then delirious; in the afternoon, brain-matter and blood began to be discharged, and a soft fungus-like growth showed itself in the wound, and the patient died, insensible, about thirty hours afterwards. At the post-mortem examination, considerable quantities

[1] Bull. de la Soc. Anat. de Paris, t. xiii., p. 13.
[2] Injuries of the Head, p. 138.

[1] Loc. cit.

of brain-matter were found protruding through the large gap made by the bullet in the sphenoid and temporal bones. The substance of the brain around the protrusion was vascular, and of the yellow color usually found in such cases. The hernia cerebri in the middle fossa of the base of the skull is now in the Museum of St. George's Hospital.

Under fit circumstances, the protrusion may occur at an earlier or a later period—it may be days, it may be weeks. After the removal of the bone everything may appear to be going on well for a long period—as long, in fact, as the dura mater remains entire; but, should anything lead to the giving way of this membrane, and should this be accompanied by inflammation of the parts beneath, protrusion may, at any time, as already mentioned, be the consequence. There are cases on record in which the protrusion did not come on until after the second month, and some are mentioned in which the interval was even longer. The usual period, however, for such protrusions is generally at the time when inflammatory symptoms are most apt to set in—that is, within a few days after the injury. Mr. Guthrie[1] states that those protrusions which are principally composed of coagulated blood usually appear immediately after, or within two days after, the accident; and that those formed of brain-matter occur at a later period, usually, although not necessarily, when the first or active inflammatory symptoms are on the decline. Facts do not, however, bear out any such rule. The blood-tumor may show itself at a period much later than that mentioned by Mr. Guthrie. In Abernethy's case, for instance, it did not appear until the tenth day after the removal of the bone. And necessarily such a tumor must vary very much as to the time of its appearance. Being, in some cases, dependent upon blood extravasated at the time of the accident, the protrusion may occur at a very early period; being, in other cases, dependent upon blood extravasated, from various causes, into the soft and ever luxuriant granulation, it cannot come into existence until later. And the protrusion of true brain-matter—and by this is not meant the escape of brain-matter which immediately follows the accident or the operation—may appear in three or four days. I have seen it on the fourth day.

What is the course of such tumors? Varying in shape and in size, according to the hole in the dura mater through which they have to pass, such tumors gradually increase in bulk, and sometimes form a large mass, overlapping and completely covering the wound in the scalp; in their progress, portions break down, become sloughy, and disappear; and, under favorable circumstances, the whole tumor may thus, in the course of time, waste away, and cicatrization of the wound follows; or, as the daily wasting takes place, further protrusion ensues, going on and on for days and days, until the patient dies; and, in some rare cases, such a protrusion has been brought suddenly to an end by the patient tearing away the whole tumor, and recovery has ensued. And experience has also proved that the protrusion may shrink, waste away, and at last disappear totally without any sloughing.[1]

But in the majority of cases the patient sinks, sooner or later, under the inflammatory processes going on within the skull.[2] And hernia cerebri is certainly a most formidable, and most frequently a fatal, affection; not so much so, however, on account of the protrusion, as of the circumstances which gave rise to it. Still there are on record a goodly number of cases in which patients recovered even after very large protrusions. Indeed, in one case, published by M. Spring,[3] the protrusion is said to have involved the whole of the left hemisphere; notwithstanding which, the patient got well and lived for eleven years afterwards, and at the post-mortem examination the left side of the cranium is said to have been found quite empty.

As to the symptoms accompanying hernia cerebri, they are those of inflammation of the brain and its membranes, running its various courses, and such as exist without any protrusion. But, in some cases, large protrusions of brain-matter may be seen with daily sloughing and reproduction, and yet with but few symptoms, and those only slightly marked. In the case referred to at page 833, of extensive protrusion from the anterior lobe of the right hemisphere of the brain, under the care of Mr. Cæsar Hawkins, at St. George's Hospital, the patient rambled a good deal, but, when spoken to, always readily answered every question put to him; there were some few and occasional twitches about the muscles of the face, and the motions and urine were passed unconsciously. The protrusion became larger and larger; portions of it sloughed away daily, and the only additional symptoms were an occasional fit of syncope, from which the patient soon rallied after taking a little wine, and some loss of power about the right arm; and this was all. The patient ultimately died from purulent infection.

The treatment of hernia cerebri is to be

[1] Op. cit., p. 133.

[1] Laurie, Lond. and Ed. Month. Jour., June, 1844, p. 478.

[2] [Of 51 cases of hernia cerebri, reported in the Med. and Surg. Hist. of the War of the Rebellion, 44 had a fatal result. Part I., vol. ii., p. 304.]

[3] De la Hernie du Cerveau, 1853.

of the simplest kind. The less the protrusion is meddled with, the better. As a general rule, removal, either by tearing away, slicing off, or ligature, is to be avoided. The parts are to be kept as clean as possible, for which purpose, gentle syringing, either with cold water or some slightly astringent lotion, may be resorted to; and the best local application is that simply of cold water. In the earlier stages, when the tumor is but small, gentle pressure may be advantageous; but in the larger protrusions, it should be abandoned. The general treatment of such cases is that appertaining to intracranial inflammation, varying according to the symptoms and the condition of the patient.

And from all this it follows, that all causes which may lead to irritation and inflammation of the parts within the skull should, if possible, be carefully removed. No splinter, no depressed fragment of bone, no foreign body should be left, if it can be got away without undue risk. At the after-death examination of one case of hernia cerebri which fell under my notice, several pieces of bone were found firmly fixed to the outer surface of the dura mater, and there was one larger fragment, of a triangular shape, which had pierced the membranes, and was sticking in the brain. The same fact has been noticed, and especially dwelt upon, by several surgeons.

Lastly, I would add, that we must be very careful, when operating, to avoid all injury to the dura mater. To admit of a protrusion of the brain, there must be, in addition to the removal of the bone, an opening of some kind in the dura mater. This membrane may not have been injured by the accident, but it may slough in consequence of being roughly dealt with at the time of the operation. We cannot, therefore, be too careful how we handle the dura mater whenever we are called upon to remove any bone; and to the evil of depriving this membrane of its outward covering we must be especially careful not to add that of unnecessarily touching and fingering it after an operation.

[Examples of hernia cerebri, illustrating the value of antiseptic treatment, may be found recorded by Mr. Annandale (Edinb. Med. Journ., Dec., 1872, p. 554), and by Dr. Elcan of Tennessee (Am. Journ. of Med. Sciences, April, 1880, pp. 426–428).

Generally, it is highly proper to make pressure on that part of a fungus cerebri, "which spreads over the scalp beyond the limits of the opening in the bone," as recommended by Prof. Agnew of Philadelphia.]

Injuries of the Cerebral Nerves.

In connection with injuries of the head, one or more of the cerebral nerves are sometimes found seriously affected in their functions; and should the patient survive, this affection, however alarming at first sight, may sooner or later pass off altogether, or nearly so; or paralysis of the cerebral nerve may remain, and, in fact, be the only evidence of the patient having had a severe injury of the head.

Traumatic affections of the cerebral nerves may coexist with, and be produced by, very different injuries of the head.

The nerve may be torn or otherwise injured by the instrument which produced the fracture. This, however, is upon the whole a rare form of injury; but some nerves are by their situation and connections rendered more liable to it than others. For instance, the olfactory, and more especially the optic and other nerves of the orbit, may be injured in a thrust wound; and such wounds, although rare, are, as already mentioned, occasionally met with in civil hospitals.

Closely connected with, and passing through, holes and canals in the bones, the cerebral nerves may be torn or injured by a fracture implicating the base of the skull. And here again it will be found that some nerves are very much more liable to injury than others. Of all the cerebral nerves, the seventh pair, for instance, is thus injured much more frequently than any other nerves. This is easily explained by the relative frequency of fractures cutting across the petrous bone, and involving the long bony canal through which these nerves have to pass; and, for ages, paralysis of the facial or of the acoustic nerve has been held as a valuable sign of fracture of the base in severe injuries of the head. But, on the other hand, it must not be taken for granted, that in every such case of paralysis the petrous bone has been broken and the nerve torn. The paralysis may, after some little time, pass off, and then it is evident that the affection of the nerve must have been connected with some other form of injury. Other nerves are liable to injury from their close connection with a piece of broken bone, and this, too, away from their bony canal.

Again, paralysis of the cerebral nerves may be dependent upon a traumatic effusion of blood at the base of the brain. And this extravasation may affect the nerve, either by pressing upon it in some part of its course, or by pressure upon the part of the brain connected with the nerve. The extravasation may ultimately be absorbed; and thus is explained that form of paralysis, not unfrequently observed about some of the cerebral nerves after an injury of the head, which lasts for a longer or a shorter period, and then gradually disappears.

The injuries of the various cranial nerves, viewed separately, present some points of

especial interest, which must now be considered.

First pair.—The olfactory may be torn across in a fracture of the base of the skull. It was so in a soldier in whom the ethmoid had been broken to pieces by a bullet.[1] But paralysis of this nerve not unfrequently occurs in cases where the head has been severely injured, without any direct evidence of fracture. In such cases we are led to suppose that an extravasation of blood was, in all probability, the cause of the paralysis of this nerve, and this extravasation may have affected either the nerve itself or the adjacent part of the brain.

In looking into these cases it will be found that the loss of smell followed such an injury as might lead to the anterior lobes of the brain being driven against the bones, and bruised. And tightly bound down in the greater part of their course to the brain by the arachnoid membrane, the olfactory nerves may in this form of injury occasionally be more or less bruised or pressed upon by an extravasation of blood.

In one case mentioned by Sir B. Brodie,[2] a gentleman met with an injury of the head which deprived him of the sense of smell. After some time, however, he began to recover from this symptom, and at the end of a year his smell was completely restored. And in another case,[3] where the loss of smell also followed a severe injury of the head, this symptom persisted without the slightest improvement many years afterwards.

In relation to the loss of smell, great care must be taken lest there be some error as to the existence of this symptom. In a case in St. George's Hospital, some years back, the patient, who was suffering from a traumatic paralysis of the face, appeared for several weeks to have lost the sense of smell upon the left side; even the strong liquor ammoniæ produced no effect, save that of lachrymation. At length it was discovered that, owing partly to a deflection of the septum towards the left side, and partly to the imperfect action of the muscles, the left nostril had become, under ordinary circumstances, impervious to air. On dilating the left nostril artificially, it was found that the patient could smell equally well on both sides.[4]

[For gunshot cases, see Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., pp. 198, 243–4, 327.]

Second pair.—The optic may be torn across in a fracture of the orbit.

In the case of a child, over whose head a cab-wheel had passed, the roof of the orbit, in addition to other extensive fractures, was broken up into fragments, and the optic nerve and straight muscles were completely torn through.[5]

[1] Jobert, Plaies d'armes à feu, p. 139.
[2] Med.-Chir. Trans., vol. xiv., p. 365.
[3] Med.-Chir. Trans., vol. xiv., p. 421.
[4] Med. Times and Gazette, 1852, new ser., vol. iv., p. 240.
[5] Bull. de la Soc. Anat. de Paris, 1837, p. 228.

This nerve is also so circumstanced that it may be pressed upon by a fragment of bone broken away from its foramen, so as to give rise to total blindness.

Such was the case in an old man admitted into St. George's Hospital after having been run over by a cart. There was a fracture with depression of one of the parietal bones; but the most marked symptom was total blindness, which was explained, at the after-death examination, by the optic nerves, immediately behind the orbits, being pressed upon by the broken sphenoid bone.[1]

But loss of sight may also be caused by pressure from an extravasation of blood connected with a fracture of the base. And this extravasation may lie either within the skull or in the orbit.

In M. A. Richard's case,[2] with evident signs of fractured base of the skull, the orbits were filled with blood, and especially the left, on which side total loss of sight was observed on the following day. The blood in the orbits

Fig. 135.

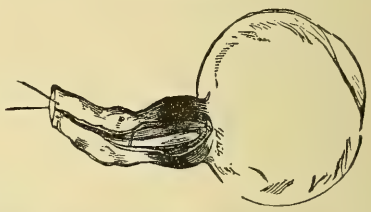


Fig. 135. Extravasation of Blood in sheath of Optic Nerve.

was gradually absorbed, and the sight of the left eye was completely restored within a month. In this case, the loss of sight was due, it was thought, to the blood extravasated in the orbit; but, in reference to this point, I would especially direct attention to the extravasation of blood which, after severe injuries of the head, sometimes takes place within the neurilemma of the optic nerve as it lies in the orbit. In severe injuries of the head, and especially those about the orbits, I have several times seen the neurilemma of the optic nerve distended with blood, which had evidently proceeded from the veins contained within this sheath. In the Museum of St. George's Hospital are two optic nerves, both taken from the same patient, in which these appearances are well marked.

Such extravasations deserve, I think, more than a passing notice, for it seems to me that blood thus situated will serve to explain some of those cases in which blindness has existed for some time after an injury of the head, and then gradually disappeared. In such cases, the nerve-fibrils are not torn or injured; the neurilemma is simply cram-full of blood; and as this blood

[1] Med.-Chir. Trans., vol. xiv., p. 348.
[2] Gaz. des Hôpit., 1854, p. 446.

becomes absorbed, sight is restored. And thus it is that I would explain M. A. Richard's case. The orbit was, it is true, filled with blood; but as it is not stated that the effusion led to the least protrusion of the eyeball, I think it more than probable that the pressure on the optic nerve was from blood within its sheath, and not from the blood in the orbit. And then, again, it is expressly stated in this case that none of the other nerves of the orbit were affected, which they, in all probability, would have been, had the paralysis of the optic nerve depended solely upon the blood in the orbit.

Third pair.—From its connections, the third pair of nerves is less liable to injury from broken bone than most of the other cerebral nerves. But it is liable to pressure from extravasated blood. A case of paralysis of the third nerve, in a fracture of the skull, is referred to by MM. Denonvilliers and Gosselin,[1] in which a clot of blood was found lying in the space between the crura cerebri. And Sir B. Brodie[2] states that he has "known a ptosis of the *left* upper eyelid connected with pressure on the inferior surface of the *left* hemisphere of the cerebrum; the pressure being so situated as to affect the nerve of the third pair immediately behind the left cavernous sinus."

After an injury of the head, all the branches of the third pair of nerves may be paralyzed. But it is curious to observe how much more frequently it is a single branch of this nerve which is thus affected. For instance, there may be ptosis of the upper lid, and this may be the only part paralyzed. Why one branch alone of this nerve should be thus singled out from all its other branches it would be impossible to say; not only may this be the case, however, but one branch of the upper division of this nerve, and another branch of its lower division, may be paralyzed at the same time, without any of its other branches being affected. It is a matter of especial interest that we should note that there may be ptosis and a dilated, immovable pupil.

A gentleman[3] fell from his horse, received a severe contusion of the head, and was taken home laboring under manifest symptoms of pressure on the brain. When, after the lapse of several days, these symptoms became somewhat abated, it was observed that the pupil of the right eye was dilated, and incapable of contraction; but his power of vision was unaffected. This symptom was accompanied with a ptosis of the right upper lid, and a numbness of the right hand. Nearly a year elapsed before the pupil was restored to its natural condition.

A man[1] fell from a height and alighted on his head: amidst other severe symptoms, it was noted, four weeks after the accident, that the left upper lid was paralyzed, and the left pupil dilated, with some impairment of the sight. The right pupil was natural. These symptoms gradually wore off; and the power of the upper lid, and the sight, were completely restored, within some thirteen months after the injury.

In both these cases it is especially worthy of note that the paralysis disappeared after a time. In the latter case it is mentioned that there was some impairment of the sight; and this might lead to the supposition that the optic nerve, too, was in some degree affected. There is no proof, however, that such an affection did in truth exist; the impairment of the sight may have been, and most probably was, owing to the dilatation of the pupil; but a simple contrivance—a card pierced with a small hole—would have settled this point.

Fourth pair.—As to the pathetic nerve, I know of no case in which it was found torn or bruised in a fractured base. The relations of this nerve with the surrounding parts will easily explain this apparent immunity from direct injury; and, even were this nerve pressed upon by extravasated blood, with our imperfect knowledge of the action of the superior oblique muscle, the exact diagnosis of a palsy of this muscle would, I think, be most difficult.

Fifth pair.—Affections of this nerve have not unfrequently been met with after injuries of the head, the paralysis manifesting itself upon one or more of its branches, and this, too, combined, for the most part, with palsy of some other cerebral nerve.

A man,[2] aged thirty-five, having, the day before, been buried by some earth falling in upon him, was admitted into the Hôpital St. Antoine, in June, 1854, in a state of perfect insensibility, and with such profuse bleeding from the nose, that it became necessary to plug his nostrils. The ocular conjunctiva, especially on the left side, was distended with blood, and so, too, were the eyelids. He gradually recovered, and then paralysis of various nerves became evident at different periods. The right upper lid and eyeball lost all power of motion. A few days afterwards, and paralysis of the right side of the face was observed; it was not quite complete, but both sensation and motion were manifestly affected. Ten days after the patient had been in the hospital, the conjunctiva of the right eye was œdematous and much chemosed; the cornea could be touched freely without flinching; it had lost some of its

[1] Maladies des Yeux, p. 821.
[2] Loc. cit., p. 351.
[3] Med.-Chir. Trans., vol. xiv., p. 354.

[1] Lond. and Edinb. Month. Journ., Sept., 1843, p. 797.
[2] Gaz. des Hôpitaux, 1854, p. 446; A. Richard.

transparency, and, at its lower part, there was a yellow spot like an interlamellar abscess. Towards the end of the month, the cornea presented a slight ulceration opposite to the yellow spot, and the facial paralysis was even more marked. Matters went on much in the same way during the month of July, with more ulceration, however, about the eye, and less paralysis of the face. Early in August the cornea gave way, and the aqueous humor escaped. Later on in the month the patient began to improve; subsequently the right cornea cicatrized, and he could see from the upper part; and, ultimately, both sensation and motion were restored to the right side. Such, as far as the fifth pair of nerves is concerned, are the details of this most interesting case.

One more case of palsy of the fifth pair. The man[1] was in St. George's Hospital in the year 1841. At the time of his admission, seven weeks after a very severe injury of the head, there was total loss of sensation on the left side of the face and upper part of the head, in fact, in every part dependent upon the fifth pair of nerves; there was no sense of taste or of feeling on the left side of the tongue, except at its root, and no consciousness of any sensation when a probe was introduced into the left nostril; and the muscles of mastication on this side had less power. Several other nerves were also seriously affected. His history was, that he had fallen from a height of twenty-eight feet, a heavy piece of timber at the same time falling upon the left side of his head. The accident was followed by perfect insensibility, for several hours, and the loss of a large quantity of blood from the ears, nose, and mouth; there had been paralysis of the right side of the body, but from this he had recovered. His intellect was sound, and he answered all questions with great precision. Very little improvement followed, notwithstanding various plans of treatment. The power of raising the left upper lid was regained, but the cornea of the left eye gradually became opaque. And when seen, many years afterwards, this man was much in the same state, save that the cornea had become somewhat more transparent.

Such is traumatic paralysis of the fifth pair of nerves; caused in some instances, no doubt, by pressure from extravasated blood, and in other instances again by some more permanent injury; at times passing off within a few weeks, at other times abiding year after year. The cases which have been mentioned were, moreover, especially selected in reference to the subsequent condition of the cornea. In the first case, in which the affection of the nerve was incomplete, and passed off altogether within four months, the cornea sloughed; but in the other case there was no sloughing of the cornea, notwithstanding the perfect palsy of many years' standing. Both cases afford good examples of the two forms of diseased action referred to in Mr. Dixon's[2] valuable paper on anæsthesia of the fifth nerve.

[1] Med. Times and Gaz., 1852, p. 240; Henry Lee.

[2] Med.-Chir. Trans., vol. xxviii., p. 373.

Sixth pair.—Paralysis of the abducens nerve occurs sometimes after an injury of the head; it may exist alone, or be combined with paralysis of several other branches. The sixth nerve may be torn across in a fracture of the base; indeed, its close connections with the petrous bone render this nerve liable to direct injury. From its slender size, and passing as it does in a groove on the superior border of the petrous bone, the sixth nerve may be snapped across in a fracture of this part of the base.

A man[1] fell from a height, and alighted on his face. He never lost his senses; merely felt shaken; walked home, and returned to his work next day. Four days afterwards, however, he began to suffer from head-symptoms, and three weeks from this time it was noticed that the right eye was drawn inwards. He went on from bad to worse, and died at the end of four months. A fracture was found running across and detaching the inner third of the right petrous bone, and opposite to this the sixth nerve was snapped asunder.

In this case, the sixth was the only nerve injured; and thus it was also in another instance, mentioned by M. Aran,[2] in which a man, after receiving a violent blow on the head, lost all power of moving the eye outwards. There was a distinct squint, for which he was operated upon by M. Maisonneuve; but with very little or no benefit.

Paralysis of the abducens not unfrequently coexists with that of some of the other cerebral nerves. Of this there are several cases on record, in which this nerve, as well as the others, gradually regained its power.

Seventh pair.—As for the facial and the acoustic, paralysis of these nerves is one of the common signs of fracture of the base of the skull. Connected as these branches are with the petrous bone, they may be, and are frequently, torn across in a fracture implicating this region. And although so closely connected—bound up in the same sheath—lodged in the same canal—one of these nerves may be injured, and not the other. Facial paralysis not unfrequently exists without deafness; and sometimes there is marked deafness, without any affection of the muscles of the face. The paralysis may be strongly marked, but it may pass off in a few months. In such cases the injury may have consisted in an extravasation of blood within the tubular sheath of the arachnoid belonging to these nerves. I have seen a small clot of extravasated blood lying between the nerves, at the bottom of the meatus internus.

Eighth and ninth pairs.—Affections of these nerves occur but seldom after injuries

[1] Journ. l'Expérience, Nov., 1843.

[2] Arch. Gén. de Méd., Nov., 1844, p. 338.

to the head. The bony canals through which these nerves pass are short, and the nerves themselves lie in the region of one of the large sub-arachnoidean spaces, the fluid of which would, by its displacement, allow room for blood to be extravasated without any great amount of pressure.

Should an affection of these nerves thus occur, however, the symptoms, in such cases, are certainly most distressing; but, however distressing, they are not always fatal, and they may even disappear altogether. A forcible illustration of this will be found in the two following cases.

In one instance[1] mentioned by Mr. Hilton, with paralysis of some other cerebral nerves, it is particularly noticed that the patient manifested much difficulty in swallowing: the tongue was thrust over to one side; articulation was slow, and enunciation very imperfect; and there was pain extending down the neck, on the side affected, as far as the clavicle. The patient had bleeding from the ears, nose, and mouth, after an injury of the head; but he recovered in a few months, and with only slight traces of paralysis left.

A grenadier[2] was struck in the region of the posterior superior angle of the left parietal by a lance, which passed deep into the substance of the brain. The lance was withdrawn a few hours afterwards, and the wound healed rapidly. The intellect was as good as it was before the injury, but the glosso-pharyngeal, the par vagum, the hypoglossal, spinal-accessory, and sub-occipital, were all paralyzed. Aphonia, dysphagia, dyspnœa, with contractions of the muscles accessory to respiration—more or less paralysis of the pharynx, œsophagus, and stomach—so that large doses of emetics had no effect;—such were some of the most distressing symptoms presented by this poor fellow.

One more case, in which the eighth pair of nerves became affected, must be mentioned, as it shows what consequences may arise by subsequent displacement of the fractured bones in an injury of the base.

A man[3] was admitted into Guy's Hospital with symptoms of concussion of the brain, and fractured base of the skull. He went on well until the tenth day, and then, after getting out of bed, and walking across the ward to talk to his wife, he was seized with rigors and vomiting, and gradually fell into a semi-unconscious state. Towards the evening appeared difficulty of swallowing, and the breathing became gasping. The difficulty of swallowing increased; and before the morning everything was rejected as soon as it reached the pharynx. He died of coma and asphyxia, within forty-eight hours after the setting-in of the serious symptoms. The brain and its membranes were healthy; there was no appearance of anything like inflammatory action; neither was the brain bruised or lacerated. A line of fracture intersecting the right foramen lacerum posterius, and running across the base, divided this part of the skull into an anterior and a posterior portion, freely movable upon each other; and the bones here were so displaced, that the right cerebellar fossa was lower than the left.

In commenting upon this case, Mr. Hilton very justly remarks that the difficulty of swallowing and breathing, which suddenly made its appearance after the man's walk across the ward, was, in all probability, caused by the displacement of the bones at the foramen lacerum posterius—a displacement by which the eighth pair of nerves was irritated, if not severely pressed upon. And as there was not the slightest trace of inflammation about the brain or its membranes, this, no doubt, is the right explanation of the symptoms which so suddenly made their appearance.

And this view of the case is borne out by Sir C. Bell's[1] two cases, in which sudden death was caused by the after-displacement of fractured portions of the foramen magnum, and consequent pressure upon the medulla oblongata.

Special treatment in injuries of the cerebral nerves seems to be of but little avail. If dependent upon extravasated blood, or any other cause removable by the efforts of nature, the paralysis will gradually disappear in the course of time; but I know of no particular plan of treatment which will help us much in such cases. At least, mercury, blistering, and other remedies usually resorted to, have not, as far as I have seen, produced any very marked benefit. And in using electricity we must be very careful lest it produce disturbance about the head, which it is apt to do, especially if employed at too early a period after the injury. On the whole, I should, in all cases of traumatic paralysis of the cerebral nerves, trust much to the restorative powers of nature.

Traumatic Inflammation of the Brain and its Membranes.

All injuries of the head, of whatever kind, may lead to inflammation within the cranium. Injuries of the scalp, apparently of the most trifling nature; injuries of the bones; injuries of the brain-substance;—all may give rise to intracranial inflammation. But some of these injuries are more apt to give rise to this inflammation than others, and, as might be readily anticipated, injuries of the brain-substance are, more frequently than any other injuries, followed by this kind of mischief.

In a wound of the scalp followed by erysipelas or diffuse cellular inflammation, cerebral symptoms often supervene; and

[1] Lancet, 1853, vol. i., p. 421.
[2] Chassaignac, Plaies de Tête, p. 93.
[3] Lancet, 1853, vol. i., pp. 24, 25, 147.

[1] On the Nervous System, 3d edit., cases cxlvi.-cxlix.

should the patient die, the morbid appearances in the majority of cases are limited to great congestion of the brain-substance, with increased vascularity of the pia mater, and effusion of opaque fluid in the sub-arachnoid tissues at the upper surface of the hemispheres.

Inflammation spreading inwards from an injury of the bone or of its coverings may be traced, as it were layer by layer, from the outer parts down to the brain; first involving the dura mater, then the parietal arachnoid, the visceral arachnoid, the pia mater, and ultimately the cortical substance of the brain.

The inflammation of the dura mater may be marked by increased vascularity, thickening, and closer adhesion to the bone; such appearances belong, however, more especially to a chronic form of mischief set up by inflammation, caries, or necrosis of the bone after an injury. In the more acute inflammation, and above all in suppuration of the osseous tissue, the outer surface of the dura mater is covered by lymph, or by pus; its tissue gets infiltrated; it may pass on to sloughing. As far as the dura mater itself is concerned, the mischief is generally confined to that part of the membrane directly under the diseased bone; but even here, in particular localities, it sometimes happens that the inflammation spreads along the cellular tissue which surrounds the branches of the meningeal arteries, and by this means reaches even down to the base of the skull.

[However, it not unfrequently happens in cases of traumatic meningitis, that purulent matter forms and collects in considerable quantity between the dura mater and the skull, directly underneath the place of injury to the latter, whence it can readily be discharged by the operation of trephining; whereby the symptoms of cerebral compression are at once relieved, and the patient is rescued from otherwise certain death. The accompanying figure (136), from the Med. and Surg. Hist. of the War, First Surg. vol., pp. 59, 60, represents the portion of bone removed from a case in point.

Fig. 136.

FIG. 136. Disc and depressed fragments of bone from right parietal. Spec. 4817, Sect. I., A. M. M.

Other examples may be found as follows: Ibid., pp. 277, 284, 286, 291. Med. and Surg. Hist. of British Army, etc., vol. ii., p. 294; P. H. Watson (Edinb. Med. Jour., July, 1870, pp. 43, 44); Syd. Soc. Biennial Retrospect, 1876–8, pp. 273, 274; N. R. Smith (Baltimore Med. Jour., Dec., 1870); Rust's Magazin, Bd. ii., p. 127; ib., Bd. xv. p. 347; Davidson (Brit. Med. Jour., Dec. 2, 1876); Callender (ib., July, 1878, p. 55); Quesnay, Mem. Roy. Acad. Surg. of France, Syd. Soc. Transl., p. 24; ib., p. 21.

A perusal of these cases will strongly enforce some lessons of much practical value. They show that sub-cranial abscesses can be opened by trephining, and their contents discharged, with successful results, when all agree that recovery is impossible unless the imprisoned matter is set free. They also show that much better results are obtained by the early than by the late performance of the operation; and that, in cases where the head is injured, the appearance of such symptoms as sudden cephalalgia, increasing in severity, located in the injured part of the head, with sense of fulness in the same part, and convulsions, or stupor and other like signs of approaching coma, demands the immediate performance of the operation. Febrile movement preceded by rigors, and glazing of the wound, when coincident, strengthen this demand. In such cases, waiting until coma and hemiplegia are fully developed before operating, lessens much of the chance of a successful issue. It should be remembered, too, that in rare instances sub-cranial abscess is caused by *contre-coup*, and that, in such cases, the trephine should be applied to the seat of pain on the side of the head opposite to that which is injured.]

In the acute cases, the inflammation, involving as it does the whole thickness of the dura mater, lays hold also of its inner surface, the parietal arachnoid, a part and parcel of the dura mater; and having once reached this serous membrane, the inflammation usually and rapidly becomes widespread. The inflammatory effusion on the free surface of this membrane is but very seldom limited to the spot first implicated. This I have, however, seen once. Under an exposed piece of bone, the dura mater was inflamed, thickened, and partially detached; and exactly limited to this spot, there was an effusion of lymph and pus on the parietal layer of the arachnoid; but all the other parts of the membranes and of the brain were quite healthy.

This is an exceptional instance, and in the vast majority of cases the parietal arachnoid is extensively inflamed, and the cavity of this membrane is filled with a quantity of fibrinous or puriform exudation of a yellowish or yellowish-green color. The effusion seldom extends, however, beyond the upper and lateral surfaces of the hemispheres; sometimes it spreads over one hemisphere only, that corresponding to the injured bone; sometimes it is found on both hemispheres, but without any effusion at the base of the skull. Occasionally, the puriform is circumscribed by the

fibrinous effusion, which may, moreover, unite the two layers of the serous membrane to each other around this part; and thus is formed within the arachnoid that kind of circumscribed collection of matter which may be, and has been, mistaken for an abscess in the brain-substance. As an instance of this, I would more especially refer to De la Peyronie's[1] celebrated case of abscess of the brain, which was, I think, simply a collection of matter circumscribed in the cavity of the arachnoid, and running down by the side of the falx, as far as the corpus callosum. This view of the case is, I think, borne out by Pott's[2] and Soulier's[3] cases, and by a case in which I found a

Fig. 137.

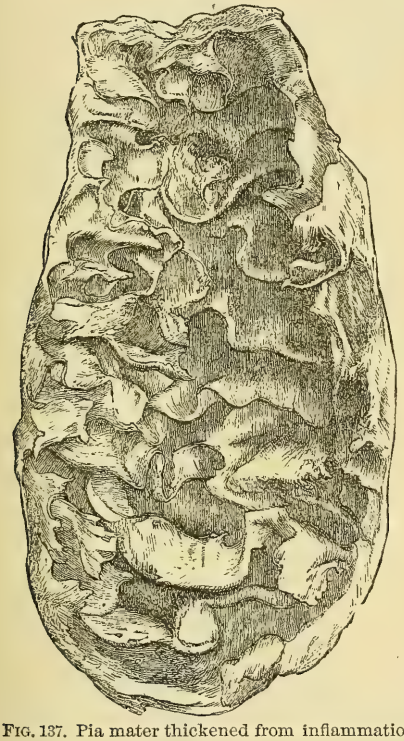


FIG. 137. Pia mater thickened from inflammation.

collection of matter in the cavity of the arachnoid thus circumscribed and running down between the left hemisphere of the brain and the falx, as far as the corpus callosum. The depth to which the matter passed in this case might easily, during life, have led to the supposition that the collection was in the brain itself.

From the arachnoid the inflammation spreads to the pia mater, and here, too, there is an extensive fibrinous or puriform exudation of a yellowish or yellowish-green color. The meshes of this membrane are filled with the effusion; and such is the thickened condition of the pia mater, in the severer cases, that it may be removed whole from the brain, and with its prolongations, which dipped down betweeen the convolutions, looks as if it had been cast in wax. Of this there are excellent specimens in the Museum of the Royal College of Surgeons, and in that of St. George's Hospital.

As in the arachnoid, so here, in the pia mater, these appearances do not generally extend beyond the convexity of the hemispheres. And all that part of the cortical substance of the brain corresponding to the inflamed and thickened pia mater is often of a dark, leaden hue; it may be, too, adherent to this membrane, and softened, and easily torn; so that, in endeavoring to pull off the pia mater, it not unfrequently happens, notwithstanding all our care, that patches of brain-substance, varying in size and thickness, come away with the membrane.

In all this, the gray matter alone, and sometimes only a thin layer of it, is involved: as to the white substance of the brain, it is simply congested, the bloody puncta being larger and more numerous than usual.

Such are the usual appearances when inflammation spreads inwards from an injury of the bone or its coverings. But occasionally it happens that the appearances in these cases differ somewhat.

On the one hand, there may be extensive effusion into the cavity of the arachnoid without any effusion in the pia mater: thus, in a case where matter was lying between the bone and the dura mater, the corresponding cavity of the arachnoid was filled with pus and lymph, covering the posterior third of the upper and lateral surface of the hemisphere, but there was no effusion in the subarachnoid tissues. Of this there are two equally well-marked cases mentioned by Sir T. Watson;[1] but according to my own experience, such cases are very rarely met with.

On the other hand, with an inflamed dura mater, covered, it may be, with lymph and pus, it sometimes happens that the arachnoid escapes, and this, too, notwithstanding an extensive effusion in the subarachnoid tissues. In a case in which the dura mater on the left side was covered with a patch of concrete lymph, and matter running from thence along the branches of the middle meningeal artery down to the base of the skull, no effusion was found in the cavity of the arachnoid; but there were

[1] Mém. de l'Acad. des Sc., 1741: "Sur le Siége de l'Ame."

[2] Injuries of Head, p. 107.

[3] Mém. de l'Acad. de Chir., t. i., p. 159.

[1] Pract. of Phys., 3d ed., vol. i., pp. 368, 369.

large quantities of sero-purulent fluid in the subarachnoid tissues covering the whole of the left hemisphere.

Such a case is a very uncommon one. There is no doubt that, in the great majority of instances of meningitis arising from an injury of the bone, the inflammatory effusions are poured into the cavity of the arachnoid. But how very rarely is anything like exudation met with in the arachnoid in the idiopathic form of inflammation! And when this marked difference between traumatic and idiopathic arachnitis is spoken of, it must be borne in mind that it is especially in this form of traumatic inflammation, arising from an injury of the bone, that the great difference exists. Traumatic inflammation of the membranes arising from an injury of the brain resembles the idiopathic form of inflammation, inasmuch as the cavity of the arachnoid is, in both forms, most frequently free from effusion.

In looking carefully to the inflammatory appearances of the membranes after concussion or contusion of the brain, the exudation will, for the most part, be found on the outside of the arachnoid, and more or less extensively infiltrating the pia mater. It is only in cases where the inflammation is very severe that effusion takes place on the free surface of the serous membrane. The exudation itself resembles that which is commonly found in inflammation of the pia mater; if puriform, it is greenish, and not unfrequently of a decidedly green color.

There are, then, two kinds of traumatic inflammation of the membranes of the brain. The one, commencing in the dura mater, and almost always reaching the free surfaces of the arachnoid; the other, commencing in the pia mater, and seldom passing beyond this membrane, and that only when the inflammation is very severe. The one, starting as it were from the bone, affects the membrane nearest to it, the dura mater; and the other, starting from the brain, here also affects the nearest membrane, the pia mater. Whilst dealing with concussion of the brain, it was particularly mentioned that intense vascularity is one of the peculiar features found about the brain-substance when death takes place some short time after the accident; and well can it be imagined that this intense congestion of the brain, if it does not pass off, will react on the pia mater; and hence the inflammation which, in such cases, manifests itself in this membrane.

Injuries of the head may also lead to inflammation of the brain-substance; and this traumatic inflammation may affect either the cortical substance only, or the deeper parts of the brain. Inflammation of the cortical substance may follow an injury of the bone, as in those cases, for instance, in which the inflammation may be traced through the various membranes to the brain, the gray substance of which, of a leaden hue, is softened, and easily carried away in peeling off the membranes. This, doubtless, is an inflammatory process affecting the cortical substance.

Traumatic inflammation of the cortical substance may also be detected in those cases where meningitis supervenes after simple concussion of the brain. Even at an early period the inflamed gray matter, of a dark-red hue, is swollen and soft, thin patches of it coming away with the pia mater, which itself is very vascular. Later on, effusion takes place in the pia mater, and the gray matter, of a darker color, breaks up and washes away under a gentle stream of water, leaving bare the white matter, much increased in vascularity, but not softened. This inflammation of the gray matter is remarkable for its extent; in many cases it occupies a whole hemisphere save the base, which generally remains unaffected.

But inflammation of the brain most frequently follows contusion and laceration of its substance. Simple concussion seldom leads to fatal inflammation, and rarely does an opportunity happen of examining the after-death appearances in a case of this kind. In the great majority of the so-called cases of concussion in which death takes place, the inflammatory process is found to be connected with, and arises from, an actual and appreciable lesion of the brain-substance.

Should the patient survive the accident for a few hours only, the whole structure of the brain, and especially that around the injured part, becomes extensively congested; so that it will require some little care to distinguish between the specks of extravasation and those of congestion. At a later period, the brain-tissue around the injured spot is of a duskier hue throughout, and the texture swollen, moist, and loose. Then follow the inflammatory exudations, reducing the substance of the brain around to a soft pulp of various colors, which flows away under a gentle stream of water, leaving the remaining part broken down and shreddy. These appearances do not generally extend much beyond the original seat of the injury; but sometimes the greater part of the hemisphere becomes involved; the white substance is then of a peculiar saffron color, which grows fainter on the outskirts, and the whole tissue is loosened and diffluent; and even should this appearance of disintegration not be at first sight plainly perceptible, it may easily be demonstrated by dropping upon the part a little water from a sponge.

Softening of the central white parts of the brain is very seldom met with after an injury of the head. The following are the only two

cases which have fallen under my own observation. A man, aged thirty-seven, died twenty-four hours after an injury of the head in a fall from a tree; the ventricles were found dilated and filled with fluid, and the fornix—remarkably soft—gave way when slightly touched; at the base of the brain, around the pons and medulla oblongata, there was a large quantity of milky puriform fluid; the substance of the brain was firm, and the puncta of blood larger and more numerous than usual; the cribriform plate of the ethmoid was broken, and the corresponding part of the brain bruised. A lad, aged thirteen, died, about three weeks after he had been thrown from a donkey and fallen on the back of his head. The ventricles were enormously dilated, and filled with serum and recently-effused lymph, and the central white parts of the brain were very soft, and broke down when slightly touched; the gray and the white substances of the brain were, throughout, very much congested, and there was extensive inflammation of the membranes; a slight fissure was found in the occipital bone, extending from the lateral sinus to the foramen magnum.

All traumatic inflammations of the brain-substance may end in suppuration and abscess, and this after contusion and laceration, and even after simple concussion. Of this I have seen two well-marked instances at St. George's Hospital within the last few years. In both cases the abscesses were large ones, and in both the formation of matter followed simple concussion.

[A case of cerebral abscess caused by concussion, may be found in the Lancet, May 17, 1873; another, from a sabre-wound, in the Med. and Surg. Hist. of the War of the Rebellion, Part I., vol. ii., pp. 19, 20. The appearances in the latter are shown in FIG. 138.

Fig. 138.

FIG. 138. Cavity of an abscess in the cerebrum, resulting from a sabre-wound. Spec. 3685, Surg. Sect., A. M. M.]

An abscess, situated in the brain, may burrow, and burst into the ventricles; such an occurrence soon proves fatal. But an abscess in the neighborhood either of the cribriform plate of the ethmoid, or of the petrous bone, may, by making its way through these bones, ultimately be discharged by the nostrils or by the ear, and the patient get well. In these cases of recovery we cannot, it is true, say positively that the matter came from the brain itself; it may have come from between the bone and the dura mater, or from a circumscribed cavity within the sac of the arachnoid. Still, if the discharge which takes place is copious, it may, I think, be safely inferred that the matter came from the brain itself, as a large quantity of matter is more apt to form in this than in either of the other situations just mentioned. The abscess may be situated close to the surface of the brain, and moreover it may chance to lie over a fracture; so that the matter would only have to make its way through a thin layer of brain-substance and the membranes.

The copious discharge of matter which suddenly took place from the ear, some weeks after an injury of the head, in Mr. Cæsar Hawkins's case, may thus have come from the brain. In his report[1] of the case, Mr. C. Hawkins inclines to the opinion that the matter came from between the bone and the dura mater; but there are two important facts which appear to me to militate against this opinion. The one, that diffuse inflammation of the membranes almost constantly accompanies suppuration between the bone and the dura mater; and the other, that had the matter really been between the bone and the dura mater, and percolated through a fracture, it would have come away gradually as it was formed, and not in a sudden burst—in a large quantity. This it is which makes me think that the case was one of cerebral abscess which had made its way outward.

Intimately connected with this subject of traumatic intracranial inflammation, there is yet one other point which has not, I think, been sufficiently dwelt upon by most of the writers on injuries of the head. I allude to the large quantities of serous fluid which are sometimes effused into the ventricles after injuries of this kind.

Fluid is poured out into the ventricles, after an injury of the head, under very different circumstances. The effusion may occur, and this is generally the case, in connection with other mischief of a more deadly nature, with acute inflammation of the membranes. For instance: in a man who died three days after having been trephined for a compound and depressed fracture of the skull, the subarachnoid tissue of the upper part of the left hemisphere was extensively infiltrated with sero-

[1] Med. Gaz., vol. xvii., p. 262.

purulent fluid, and all the ventricles were enormously distended, and filled with a clear, transparent serum; the lining membrane being, throughout, rough, and as if sprinkled with the finest white sand. The septum lucidum was exceedingly thin. The structure of the brain was quite healthy.

But accumulation of fluid within the ventricles, following an injury of the head, may sometimes be the only morbid appearance; and this effusion may be more or less gradual: days, weeks, months, may elapse before any decided symptoms make their appearance.

Of such cases Dr. Abercrombie relates two strongly-marked instances in his work on Diseases of the Brain, pp. 151, 152. In both these cases the effusion was slow, and the symptoms came on gradually. But the effusion may take place suddenly; symptoms of imminent pressure are present, and, with a scalp-wound and bare bone, may lead to an error in diagnosis, and the application of the trephine.

A middle-aged man fell in the street, and was picked up insensible, with some arterial bleeding from a scalp-wound at the upper and back part of the head; the bone was not exposed. He remained in a state of collapse for some time, and when he began to rally he became so violent that two men were obliged to hold him down. It appeared that, on the previous day, he had had, for the first time in his life, some kind of convulsive fit, but without any frothing at the mouth. He was freely purged, and on the following day, as he complained of intense pain in the head, he was bled to ten ounces. The pain continued, and thus he went on for several days with intense pain, notwithstanding that he was bled several times, and put upon calomel and henbane. On the sixth day, the bone under the scalp-wound became exposed, and the soft parts in the neighborhood slightly œdematous. On the seventh day, early in the morning, this man was seized with hiccough, and suddenly fell into a state of coma; the insensibility was complete; the pupils acted well; there was no stertorous breathing; the pulse was feeble and running. A short time afterwards, it was determined, at a consultation of several surgeons, that a trephine should be applied over the exposed bone, in case there should, perchance, be any matter between the bone and the dura mater. No matter was found. The bone and the dura mater were healthy. The patient continued much in the same state, and died in the evening. Some serous effusion was found between the arachnoid and the pia mater, especially at the base of the brain; there was no lymph in any part; the membranes were quite transparent, and the pia mater not congested. The ventricles were dilated, and filled with a large quantity of fluid; the brain itself was watery throughout, and soft. In one of the convolutions, at the base, there was a small tubercular deposit, of the size of a pea, and around this the parts were soft and injected to about three lines in circumference. No tubercular matter was found in any of the other organs, which were all sound.

What are the symptoms of traumatic intracranial inflammation? Amongst the first symptoms usually noticed will be pain in the head, more or less intense, sometimes confined to the seat of the blow, sometimes spreading from this over the whole head; feverishness, with a hot skin and increased pulse; contraction of the pupils; intolerance of light and of sound. As matters get worse these symptoms increase, become more and more marked, and are soon followed by disturbance of the brain-functions; sickness, restlessness, constant tossing about, convulsions, delirium; then drowsiness, oscillation and dilatation of the pupils, twitching and spasms of the muscles, coma, relaxation of the sphincters, paralysis, and, as indicative of suppuration, rigors.

Such are the varied symptoms at different stages of inflammatory mischief following an injury of the head. In some cases all these symptoms may be present, and even manifest themselves in this regular order of succession. But in most cases the symptoms vary much in many respects. Cases may be met with in which some of these symptoms are altogether wanting; and in other cases, again, a single group of symptoms, or some one symptom or another, may be strongly marked. Indeed, in practice, it will be found that these variations give, as it were, to each case special features of its own—features which may render the case more or less difficult of diagnosis as to its real nature.

In enumerating these symptoms, injuries of the head have been spoken of as a whole. And now arises the question, whether traumatic inflammation dependent upon one form, can be distinguished from that dependent upon another form of injury. Can it be said, in this case, that the brain alone is affected, and in this case, that the mischief is confined to the membranes? I believe not.

In a case of concussion and scalp-wound, it cannot, for instance, be said positively, from the symptoms, that they depend upon inflammation of the brain-substance and its investing membranes connected with the concussion, or upon inflammation of the parietal membranes connected with a contusion of the bone. Neither can we say positively, when suppuration takes place, that the matter is immediately under the bone, or within the brain-substance. True it is that this cannot be done. But an inference, and a good one too, may, I think, be drawn from the time at which the symptoms of inflammatory mischief begin to show themselves. If the inflammatory symptoms are dependent upon concussion, they will be apparent at a very early period after the accident; indeed, in many cases, they begin within a few hours: and this is

what might have been expected from the intense congestion which exists in the brain-substance and its investing membrane, the pia mater, after a severe case of concussion. In contusion of the brain-substance, on the other hand, it often, nay generally happens that the symptoms of inflammation do not set in till the fourth or the fifth day; all effects of the injury may appear to have passed away up to that period, and then comes the train of symptoms indicative of inflammation. But in inflammation spreading from a contused bone to the parietal membranes, the mischief may smoulder for a time, for many days, for two or three weeks, and then suddenly burst forth.

The period at which the inflammatory symptoms begin after the accident, may, then, be of value in our endeavors at establishing a diagnosis, and especially if there be any local signs about the bone to guide us.

Attempts have been made at a differential diagnosis of inflammation of the various parts and structures of the brain. Inflammation of the upper and under parts of the brain may be, it is said, distinguished from each other; and so, too, it is said, may inflammation of the lining membrane of the ventricles, as well as inflammation of the cortical, be distinguished from that of the tubular structure.

I cannot, however, say that I think we are at present really in a position to go so far as all this. To take an example from two of our modern teachers. "Inflammation of the tubular portion of the hemispheres is characterized by the appearance of convulsions previous to any sign of mental excitement." Such is Mr. Solly's[1] opinion. And Sir T. Watson's:[2] "When the attack comes on with a sudden fit of convulsion, the inflammation has commenced in the pia mater, or arachnoid." Can anything illustrate more forcibly the difficulties by which we must be surrounded whenever we may attempt to draw an accurate diagnosis of the exact parts of the cranial contents involved in an inflammatory attack?

It must be borne in mind that convulsions, that is, convulsions violently affecting the whole body, may make their appearance, after an injury of the head, under very different circumstances. They may come on immediately, or shortly after the accident; they may come on a few days after it. In the first instance, they can, as a matter of course, have nothing to do with inflammation; they may pass off just as suddenly as they came on, and leave the patient without a single sign to denote that they arose from any actual lesion of the parts contained within the skull. And even in the second instance, making their appearance at the period when inflammation usually sets in, the convulsions may lead us to suppose that there is inflammation, when it does not exist in reality. This I have seen now and then, and some well-marked instances of this state of things are mentioned by Sir B. Brodie.[1]

Next, we have to deal with the treatment of this traumatic intracranial inflammation. And, first, as to bloodletting. Strange it is to read of the enormous quantities of blood drawn from patients, under such circumstances, in former times, and even but a few years back. Some cases, it is true, recovered after this heroic treatment, and nothing short of this, it is said, could have saved the life of the patient. But the practice of the present day in the wards of our large hospitals tells a very different tale. For years past, I have never seen any of those frightful bloodlettings which I used to witness in the early part of my career. Even in intracranial traumatic inflammation we are nowadays much more sparing of blood—and rightly so, too.

Whenever blood is to be drawn from the arm, the general condition of the patient should be carefully looked to, and, if the loss of a few ounces only of blood produce an intermission, a sinking of the pulse, the blood should no longer be allowed to flow. The patients with whom we have to deal in the present day certainly do not require, neither could they, I think, bear the loss of much blood. I am speaking now of the patients, such as I find them in the wards of our London hospitals. They, at any rate, certainly do not require much bloodletting. If it be thought absolutely necessary to draw blood from the arm, it had better be done by small bleedings, repeated at intervals according to circumstances. It is on all accounts better to act thus circumspectly than to try to cut short the inflammatory attack by large bleedings. And in every one of our bleedings, not only ought we to look to the general condition of the patient, and the state of the pulse, but most careful should we be to examine the blood, not so much for the sake of seeing whether it is buffed and cupped, as for the relative proportions of the solid and fluid parts of the blood. A large amount of serum with a small clot tells us that we cannot with safety proceed further with our bleedings.

Some years ago, I watched a case wherein repeated bleedings, within a short time, were resorted to for supposed intracranial inflammation after concussion. A few hours after the last bleeding, which, although a

[1] On the Brain, 2d edit., p. 457.

[2] Lectures on the Practice of Physic, 3d edit., vol. i., p. 384.

[1] Med.-Chir. Trans., vol. xiv., p. 367.

small one, appeared to me, when ordered, not to be required, the patient suddenly became perfectly comatose and died some nine hours afterwards. There was not a vestige of pus or of lymph in any part within the skull, but large quantities of water had been effused into the ventricles, and some water was also found in the subarachnoid tissues. The other organs were all healthy. I have always thought that this patient died of over-bleeding.

In many cases, after the first bleeding from the arm, it is most advantageous, should further bloodletting be deemed indispensable, to resort to local bleeding by means of leeches applied to the head, or cupping on the nape of the neck. It was a favorite practice with Sanson to have leeches applied "en permanence," in different parts of the head, at different times; and especially on the temples, and over the mastoid processes.

As a matter of course, the room is to be darkened, the head shaved, and raised higher than usual.

Purging, free purging, is to be brought into play as soon as possible. It is a most valuable remedy, and one upon which all practical men very justly lay great stress, and none more so than Dr. Abercrombie, who does not hesitate to say that, according to his own experience, more recoveries from head-affections of the most alarming aspect take place under the use of very strong purging, than under any other mode of treatment.

And then comes the local application of severe cold to the shaved head. This is a powerful remedy, and not to be used without all due caution, for the effects of it are sometimes most striking. If thought necessary, pounded ice, or the cold douche, are the means the most readily obtained and used in such cases.

One of the earliest remedies should be mercury, calomel in small doses, and frequently repeated until the gums begin to be affected. Is opium to be combined with it? About this there is great diversity of opinion. By some surgeons, opium in these cases is strongly condemned; by others, it is used without scruple. I have frequently seen calomel and opium prescribed in traumatic inflammation of the brain and its membranes, by some of the most practical and best surgeons, and I must say, without any of the drawbacks, as far as I could perceive, so commonly adverted to. And opium, or, better still, morphia, is doubtless of great value in many cases presenting some of the most characteristic symptoms of inflammation. In furious delirium supervening a few days after an injury of the head, with well-marked symptoms of an inflammatory attack, calomel and morphia are of the utmost use. Of this, abundant proofs are to be found in the best authorities; and practically, I have several times witnessed the beneficial effects of these remedies in such cases.

Antimony I have always avoided. I know that it is frequently used by some surgeons of great eminence; but I have always been afraid of the vomiting which it might produce. It is an uncertain remedy in this respect, and I have often seen even a small dose produce sickness.

Are we to use blisters? Not, I think, in the first stage. Later on they often prove most beneficial, and may be applied over the head, or nape of the neck. The French surgeons, however, and especially Boyer, advocate the early use of a blistering-cap to the head. And should a blistering-cap have been thus applied, great benefit may, occasionally, be derived from the use of mercury to the blistered surface, which, in fact, is to be dressed with mercury.

[In cases of traumatic inflammation of the membranes and substance of the brain, no remedial measures known to the writer are at all comparable, after bloodletting, to the ice-bag persistently applied to the head, and the administration of mercury. To retard or prevent the occurrence of suppuration, in such cases, nothing equals ice applied by means of the ice-bag to the affected part. In urgent cases calomel should be given in purging doses (grs. x to xxx); in subacute cases in alterative doses (gr. ½ to gr. j. every four hours); and in chronic cases the bichloride should be administered, in solution with the compound tincture of gentian, thus:

℞. Hydrarg. Chlorid. Corrosiv., grs. ij.
Tinct. Gentianæ Comp., . ℥iv.
M.

One teaspoonful may be given thrice a day in water; making an elegant as well as an efficient prescription. Moreover the writer has found in his experience that corrosive sublimate is oftentimes a useful tonic. Many times he has seen much good done by the remedial measures mentioned above in cases belonging to the category now under consideration.

The importance of *rest*, complete and protracted, of mind as well as of body, as recommended by Mr. Hilton in cases of traumatic inflammation of the brain and its membranes, cannot be too strongly insisted on; and Prof. Agnew's statement that he is acquainted with "no single remedy comparable to calomel in preventing meningitis and encephalitis," should not be forgotten.]

In estimating any plan of treatment in cases of inflammation after injuries of the head, great care must be taken to examine thoroughly into the state of the different

viscera, and especially of the kidneys. This is a point to which I have already more than once adverted; and feeling as I do, from practical experience, the absolute necessity of not overlooking this matter, again do I allude to it in this subject of traumatic inflammation.

A healthy or a diseased condition of the kidneys may not only lead us to modify our treatment, but our views of the case in hand, knowing, as we now do, how it sometimes happens that the very symptoms about the head are dependent upon the diseased condition of these viscera.

If recovery takes place after intracranial inflammation, the patient should be put upon his guard against running any risk of a relapse; and especially should he be cautioned about his mode of living, and his future habits for some time to come. There is, it is well known, no class of cases which require more after-care, and none in which a relapse is so apt on the slightest provocation to take place.

But notwithstanding all our endeavors, the inflammation may get ahead; symptoms of pressure follow; and then comes the question of applying the trephine.

In discussing the question of perforating the skull in contused bone, and in fractures with symptoms of intracranial suppuration, it was settled that the dura mater is to be divided if there are evidences of matter underneath this membrane; that is, if the dura mater, tense, and without any pulsation, bulges into the trephine-hole; and some cases were mentioned in which the patient's life had been saved by this proceeding—cases in which circumscribed suppuration had occurred within the arachnoid. But nothing was said about the treatment of abscess within the brain-substance, such abscess not being necessarily connected either with contusion of the bone or with fracture.

[With regard to circumscribed abscesses of the arachnoid, *i. e.*, intermeningeal abscesses, and their treatment by trephining the skull, incising the dura mater, and discharging their contents, cases supplementary to those given in the text may be found as follows: Med. and Surg. Hist. of War of Rebellion, First Surgical vol., p. 279; Pirogoff (Am. Journ. of Med. Sciences, July, 1863, p. 63); Schmucker (ib., pp. 62, 66); Lohmann, Mursinna (ib., p. 63); P. H. Watson (Edinb. Med. Jour., July, 1870, pp. 40, 43); Houillot (Med. News and Abstract, 1880, p. 39).]

An abscess may form in the brain after any and every kind of injury of the head; and it is with this abscess, which may give rise to the symptoms of pressure, that we have now to deal.

In such a case it may occur that the matter in the brain is let out by simply taking away a piece of the bone, the dura mater underneath being in a sloughy condition.

Thus it happened in a case at St. George's Hospital, a few years back, under the care of Mr. Cæsar Hawkins. The trephine was applied over an exposed portion of the left parietal for well-marked symptoms of compression of the brain which had come on a month after the accident. The operation was performed under the supposition that matter would be found between the bone and the dura mater: but such was not the case; the dura mater proved to be in a sloughy state, with an opening, of the size of the thumb, through which escaped a quantity of very foul matter and brain-like substance. The man died five days after the operation; and then was found in the back part of the left hemisphere a good-sized abscess, extending down to the lateral ventricle, into which it had nearly burst.

It happens more frequently, however, that the dura mater is not in this sloughy state. One is led by the symptoms to divide this membrane, and then, finding that this affords no relief to the symptoms, is one warranted in cutting into the brain in search of an abscess? The warrant in such a difficult matter necessarily depends upon the circumstances. Should there be good reason for believing that a cerebral abscess exists under, or in the neighborhood of, the part of the skull perforated, there is no doubt that one would be warranted in incising the brain.

Roux[1] laid open the dura mater, and finding nothing under this membrane, proceeded no further. The symptoms increased, and the patient died in a few days. Immediately under the cortical substance of the brain was a large abscess, situated a little below and behind the spot trephined. The matter might easily have been reached by a very slight cut in the brain at this part, and in such a case, with decided symptoms of compression, one may well regret that no attempt at all was made to find the matter.

J. L. Petit[2] was more fortunate in the issue of his case of traumatic abscess of the brain. This celebrated surgeon trepanned the head of a child, nine years old, for a compound fracture with depression. Feverish symptoms set in on the fifth or sixth day; on the following day the wound was dry, and the dura mater, of a darkish-brown color, bulged into the trephine-hole: evidently there was matter under the dura mater; this membrane was divided, and a tablespoonful of brown, fetid serosity escaped. The symptoms were not relieved by this operation, but nothing further was done. Matters went on from bad to worse, and there was but little hope left, when on the second morning after the operation, the little fellow appeared to be much better. The improvement which had taken place was explained when the head was dressed; a large quantity of foul pus was found in the dressings, which were

[1] Chassaignac, Plaies de Tête, p. 192.
[2] Mal. Chir., t. i., p. 91.

saturated with it, and this had come from a large abscess in the brain, which had burst during the night. The patient was quite well within two months afterwards.

It was the fortunate issue of this case which, doubtless, led M. Velpeau[1] to recommend delaying the incision into the brain whenever the symptoms are not very urgent. In thus delaying, M. Velpeau thinks that if matter existed in the brain, it would, in all probability, gradually push its way towards the trephine-hole, and, at any rate, render the operation less hazardous.

Dupuytren,[2] far from waiting thus, at once plunged a knife into the brain, and thereby, in all probability, saved the life of his patient. A young man was struck on the top of the head, in a brawl, with a knife, the blade of which broke in the bone, after having perforated the skull; but the exact nature of the injury was overlooked by a surgeon, who simply brought the lips of the wound together. The wound healed readily, and everything went on well for several years, save some occasional pains about the scar. This man was subsequently admitted into the Hôtel Dieu in a state of stupefaction, into which he had suddenly fallen. On examining the scar, a foreign body was clearly felt underneath it, and this, when laid bare, proved to be the point of the knife. The trephine was applied; the symptoms nevertheless continued, and paralysis of the opposite side of the body made its appearance. The dura mater was now laid open; nothing was found under this membrane; a knife was therefore plunged into the brain, and immediately a large quantity of matter flowed out. That very night all the symptoms disappeared, and the patient ultimately recovered.

Dupuytren's bold proceeding was followed by complete success. And so, too, might De la Peyronie[3] have been equally successful, had he been allowed to do that which he wished. A man was trepanned, and a large quantity of matter was evacuated from under the bone, with great relief to the symptoms. On the second morning, however, the symptoms were as bad as ever. De la Peyronie laid open the dura mater, and, finding nothing there, proposed cutting into the brain; but this was declined. The patient died. An abscess was found in the brain at the depth of three or four lines, and immediately underneath the opening in the skull. [See also, Hennen (Military Surgery, p. 258, Am. ed.)]

And within the last few years, a surgeon[4] has been bold enough not only to make several different cuts into divers parts of the brain for a traumatic abscess, but even to lay open one of the lateral ventricles for the evacuation of matter therein contained. In this case a man, aged forty, met with a severe compound fracture of the skull, and ultimately lost several pieces of the frontal bone. He did well, but five weeks after the removal of the bone, cerebral symptoms made their appearance. The scar was laid open, and three more pieces of loose bone were taken away. The symptoms still persisting, Dr. Detmold was led to think that there was an abscess in the brain. The scar was now dissected off, with the portion of the dura mater to which it was attached; an incision an inch long and half an inch deep was then made into the brain-substance, and a thick stream of healthy pus flowed out. The symptoms were at once relieved, and the patient progressed most satisfactorily until hernia cerebri occurred. This was kept down by pressure; and on the eighteenth day after the opening of the abscess, the patient was about, a hole through which a probe could be passed into a cavity in the anterior lobe of the brain still remaining. Three weeks afterwards, although he felt very well, this man began to lose his memory; he even forgot his own name, and could no longer read nor write. The parts involved in the injury became hot and swollen, and stupor reappeared. A fresh incision was made through the integuments into the brain, but this time no matter followed; the symptoms, however, appeared to be greatly relieved. Dr. Detmold probed the wound, and found that the instrument passed four inches and a half into the brain towards the lateral ventricle, into which it was thought that the abscess had burst. The patient continued to mend for a time, but five days afterwards he became speechless. It was then thought advisable to explore for more matter; and seven weeks after the incision, another one, an inch and a half deep, was made into the brain, and a probe passed in nearly five inches. Shortly after, matter flowed freely through the wound. The patient sank the same evening. Both ventricles contained a large quantity of thin pus, and at the anterior corner of the roof of the left one there was the last incision. The brain itself was vascular, and nothing more.

There are many bold deeds in the records of surgery appertaining to injuries of the head, but Dr. Detmold's must be classed amongst the boldest. The first incision certainly saved the man from impending death; and, in the state that he was subsequently in, it might be argued that he was none the worse off for the other incisions, which offered him the only chance of safety, if chance of safety there was. Few surgeons will, however, be found to follow Dr. Detmold's example.

[Are abscesses in the brain ever spontaneously cured, like blood-clots in the brain? The practical facts are all against the idea of curability; nevertheless, the development of firm cyst-walls, in some cases, shows a disposition to spontaneous cure. In such abscesses, it is usual to find the pus very degenerate, *i. e.* granular and fatty; this would favor its absorption, and the occurrence of other changes which, in other abscesses, would be thought to point to a cure (Syd. Soc. Retrospect, 1867–8, p. 56). But there is no case on record wherein a cerebral abscess has undergone a spontaneous cure. Practically, this fact settles the question of treatment. The sole resource of the surgeon, then, in managing collections of matter in the brain or

[1] Plaies de Tête, 1834, p. 87.
[2] Bless. par Armes de Guerre, t. ii., p. 146.
[3] Sabatier, Méd. Opér., 1832, t. ii., p. 65.
[4] Amer. Jour. of Med. Sc., N. S., No. 37, p. 86.

its membranes, is to let it out. The operation should not be unnecessarily delayed; the vent to the matter should be sufficiently free, and should be kept so until the cure is complete.

Puncturing the cerebral substance for abscess being admitted to be a justifiable operation, the surgeon naturally inquires next concerning the utility of this procedure, and the best method of executing it. These questions can best be answered by referring to successful examples, as follows: Dr. J. F. Weeds (Nashville Jour. Med. and Surg., April, 1872, p. 156); Mr. Holden (St. Bartholomew's Hosp. Rep., ix., p. 96; Syd. Soc. Retrospect, 1873–4, p. 257); Mr. J. W. Hulke (Med.-Chir. Trans., vol. 62, or Am. Jour. Med. Sciences, July, 1880, p. 232).

The procedure employed in this latter case, *i. e.*, exploring the brain-substance with a fine trocar, belongs unquestionably to the best kind of good practice, and should be used in all analogous cases before thrusting in a bistoury; for puncturing the brain with an exploring needle or a fine trocar would do but little harm, even if matter were not discovered.

The last three cases serve well to mark a great advance in practical surgery. The operations were particularly brilliant, and deserve to be placed in surgical literature beside those of J. L. Petit, Dupuytren, and Detmold.

Two cases of traumatic abscess of the brain that eventuated in recovery, after evacuation by operative procedures, were reported in our late civil war (Med. and Surg. Hist. of the War of the Rebellion, First Surg. vol., p. 280; ibid., pp. 280, 281).

Five additional cases of traumatic abscess of the brain, in which recovery ensued on properly giving vent to the matter, etc., by operative procedures, are noted in the Am. Journ. Med. Sciences, July, 1873, pp. 66, 67.

When the orifice in the membranes is allowed to contract or to become choked by granulations so as to obstruct the outflow of the discharge, before the abscess-cavity is healed, this cavity becomes refilled, the symptoms of cerebral compression return, and the patient dies, unless the outlet is promptly re-opened by an operation. Thus in Pancoast's case (Treatise on Operative Surg., 2d ed., p. 106), at the end of sixteen days the flow ceased, coma returned, and the man died. Dissection showed that the orifice in the dura mater was too small, and blocked up with fungous granulations. The abscess had refilled and burst into a lateral ventricle. It is, then, an important indication in the after-treatment of cerebral abscesses that have been incised, to keep the orifice well opened, and to make the abscess itself heal from the bottom. The same requirements obtain in the after-treatment of intermeningeal (arachnoid) abscesses.

When the diagnosis of cerebral abscess is clear, if one puncture with an exploring needle or an exploring trocar fails to find the matter, another puncture should be made, and so on, until the matter is found. In a case operated on by Maisonneuve (L'Union Médicale, 1853, p. 48), the matter was not reached, although the autopsy showed that, had the fifth puncture been one centimetre deeper, the abscess would have been evacuated.

But cerebral abscesses sometimes form on the side of the brain opposite to the part of the head that is struck, in consequence of injury by *contre-coup;* thus, where a blow has been received on the upper part of the head, the abscess will sometimes be found near the base of the brain. In a case of this kind reported by Pigray, the abscess was very small, and did not prove fatal until six months after the casualty. Cerebral abscess, resulting from injury by *contre-coup*, generally causes some symptoms which excite suspicion of its presence. These symptoms are fixed pain at the seat of injury by *contre-coup*, paralysis of an arm or a leg, or even complete hemiplegia on the side of the body opposite to the seat of fixed pain in the head, *i. e.*, on the same side as the part of the head that is struck, together with irregular shiverings, and fever. The doctrines of cereberal localization, mentioned elsewhere, may furnish important aid in determining the site of such an abscess. Should the diagnosis of central abscess from *contre-coup* be clear, the operation of trephining and puncturing, accordingly, would be justifiable; for, thus the matter might be let out, and the patient saved.

It is still necessary to mention some expedients which should be employed in treating all wounds of the head, whether the result of accidents or of surgical operations, all suppurating sores, and all abscesses after their evacuation, whether of the scalp, or of the diploë, or of the meninges, or of the brain itself. In all such cases antiseptic dressings should be continuously applied, for, by so doing, the cure is generally hastened, and thus many patients are saved, who otherwise would be lost. Experience has shown that antiseptic dressings prove especially salutary in lesions which extend to the skull, or the membranes, or the substance of the brain. The risks of trephining are much lessened by antiseptic treatment. Sub-cranial, subdural, intermeningeal, and cerebral abscesses should, generally, be thoroughly cleansed, at least once daily, with a one per cent. (or at the utmost a two per cent.) solution of carbolic acid in water, and the ex-

ternal opening should be kept covered with compresses wet with the same solution. Drainage-tubes should be inserted whenever they will facilitate the discharge, or prevent the accumulation of matter in these cavities. The utmost cleanliness and purity of air in the hospital ward or sick-room should be maintained. In cases where suppuration is going on the diet should always be nourishing and easily digestible; and the bitter tonics, with iron and alcoholic stimulants, are often required.]

INJURIES OF THE FACE.

By Holmes Coote, Esq.

Revised by Charles T. Hunter, A.M., M.D.

The human face, the front and most exposed part of the body, would be more frequently the seat of injury were it not for its comparatively small size, the great mobility of the head, and the mechanically protective articulations of the forearm and hand. Of the first it is unnecessary to speak. As regards mobility, the head can bend backwards and forwards, and also rotate in no small circumference upon a horizontal plane; and to this the effect of the general mobility of the vertebral column is to be added. The obliquity of the inferior extremity of the humerus from without, downwards and inwards, brings the hand in flexion immediately in front of the mouth. With these means of guard, the head and face, guided by the eye, readily escape common accident; and those injuries which befall it are for the most part sudden, and often violent.

The skin of the face is not quite similar to that of other parts of the body. It is more abundantly supplied with minute vessels, which partake of the character of gland-vessels, in being able to propel, without the heart's influence, an additional amount of blood to the surrounding tissues. The nerves, the sebaceous, and sudoriparous follicles are highly developed, and the dermal structure is intimately united to the layer of subjacent muscles, whose action, impressing lines upon the skin through the subcutaneous adipose layer, gives impress to the features, and imparts the stamp of character to the individual. The bones of the face lack the density of the bones of the extremities; they are either thin and paper-like, or thick and spongy; but in both instances vascular, and little prone to exfoliation from common causes. They bleed when cut; and yield to distension, and are capable of recontraction; they are subject, moreover, to the morbid changes, such as are witnessed in the softer tissues, and they unite readily when broken. Injuries to the face, then, may be appalling to the bystander, but they excite far fewer feelings of dread in the mind of the surgeon. A soldier in warfare receives a sabre-cut across the face; the wound may gape and look ghastly, but it is in general curable. An artisan is struck with a winch-handle violently upon the cheek; he is seen with distorted features and in wild delirium; but the stress of the injury is recognized as limited to the face; experience shows that the commotion of the brain will subside, and teaches that the prognosis is generally favorable.

Erysipelas is an accident which not uncommonly complicates these cases. Commencing about the seat of injury, it spreads over the entire head, where its presence is dangerous from the proximity of the brain, and the close vascular connection between the parts within and without the skull.

But, these evils guarded against and avoided, there is still, in the event of recovery, the chance of deformity, of unpleasantness of expression, or of impairment of movement in parts essential to the integrity of an important organ, such as the covering of the upper lid to the transparent

cornea of the eye. To all these points the surgeon must direct his attention in the selection of such measures from the commencement as are best calculated to insure relief.

Bruises.

Blows on the face are commonly followed by extravasations of blood, which, as in the familiar instance of a black eye, are seen, in their various phases of transformation and absorption, passing through the shades of color from deep brown, brownish or yellowish green, pale straw hue, to the natural aspect, through the thin integuments of the face. It not uncommonly happens that, in connection with the bruise of the skin, there is extravasation of blood under the conjunctiva, or in the anterior, or even posterior chamber of the eye. These injuries are interesting, both pathologically and surgically. In the first instance, as showing what becomes of extravasated blood, and how soon it may become absorbed. In the second place, as affording an opportunity of testing how far we are in the possession of means calculated to assist and to expedite the efforts of nature.

I believe that, unless circumstances of unfavorable character interfere with the processes of repair, the rapidity with which effused blood is removed by the unaided action of the absorbents has been much under-estimated; it seems to be the very first step towards recovery, and its retardation implies the existence of some disturbing or morbid influence.

In 1837 a boy aged ten was brought into St. Bartholomew's Hospital with a bruise on the brow, and with effusion of blood into the anterior chamber of the eye, from a blow, to such a degree that neither pupil nor iris could be seen. During the course of the night so large a quantity of the blood had been absorbed from the eye as to leave the pupil visible; and at the end of the sixth day from the accident the anterior chamber was clear, there being only a stain of blood upon the surface of the iris, indicating, in all probability, the exact spot where the bloodvessel had given way.

So in bruises of the skin and subjacent parts, the removal of effused blood commences immediately upon the receipt of the injury, and goes on with a rapidity proportioned to the healthy state of the individual and the activity of circulation in the surrounding parts. Pugilists, who are brought into high condition by the usual system of training, recover from the bruises which they sustain in the exercise of their calling in from six to nine days. "However much a man may be beaten about the head," explained one of the fraternity to me, "he is 'himself again' in little more than a week, provided he keeps from drink, and takes an occasional dose of opening medicine." Experience has shown these men that they may take animal food with impunity, but that stimulants in the shape of drink interfere with and retard the removal of the bruise. The only exception to this statement respecting rapid absorption, is in the case of the effusion of blood between the conjunctiva oculi and the sclerotica. Here a space of four or six weeks may be necessary for the removal of the stain; but, then, we must remember that in the normal state there are but few vessels of any kind engaged in active work in either tunic. We do not in the present day bleed a patient in consequence of a bruise; neither do we employ stimulating lotions nor frictions to the affected part. An evaporating lotion may be used if there are heats, and the patient feels the application grateful; but the best treatment consists in abstinence from drink (unless under exceptional circumstances), in rest, and the occasional administration of aperient medicine. I have not witnessed any clearly-marked beneficial effect from the employment of tincture of arnica, as recommended by many surgeons. It may be used in the same strength as spirits of wine, in the proportion of one part to eight or ten of water, as a lotion, and it will at least serve to occupy the patient's mind. But the stories of its almost miraculous powers are without foundation, and exist only in the imagination. It may be rubbed into the bruised part, either undiluted, or mixed with an equal part of water; or the patient may use friar's balsam, or any stimulating liniment instead. These applications serve only to excite the circulation, a measure usually unnecessary as regards the head and face, and capable, if in excess, of inducing a result totally opposite to that for which it was intended.

The practice of making a puncture into parts distended with extravasated blood, in order to preserve the vitality of the skin, is rarely necessary in injuries to the face. The only parts to which such a measure can ever be applicable are those where the subcutaneous tissue is very loose, and easily distended, the skin being of extreme tenuity, such as the upper eyelid; but even here we have rarely occasion to do so.

The question of rapid or of slow absorption of blood is one of practical importance; for by its proper solution we may justly estimate the progress of the case. In contrast with the rapid recovery of the pugilist, we may put the case of a pallid, feeble, and under-fed woman, bearing upon her person the marks of ill-usage. It is no uncommon thing to see in such a person the mottled-yellow ring around the eye, telling its tale of the blow inflicted by a

brutal hand, persisting, with but little change, for many weeks. Under such circumstances the treatment would be different, a more generous diet being advisable. But even here I question much the value of stimulating or other local applications. In the forehead, extravasated blood presents itself under two conditions. There may be a simple cutaneous bruise, or there may be a collection of fluid blood under the occipito-frontalis. We have already discussed the former species of injury. The latter may be dismissed with a few words, as it will be found more thoroughly treated in the essay on INJURIES OF THE HEAD (see *ante*). One of the larger vessels of the forehead, bruised or otherwise damaged by a blow, gives way some days after the accident, and pours forth a considerable quantity of fluid blood. An examination conveys to the hand of the surgeon the sensation as if there were a circular depression of the skull surrounded by a sharp ring of bone. The explanation of this feeling is not obvious; it is in no way connected with the composition or the coagulation of the blood, for it is felt whenever fluid in moderate quantity is contained in a yielding yet thick-walled cyst. [The condition of the tissues of the forehead resulting from severe contusion, which, on examination, "conveys to the hand of the surgeon the sensation as if there were a circular depression of the skull surrounded by a sharp ring of bone," according to Prof. Agnew,[1] finds a satisfactory explanation in the anatomy of the superficial fascia. The impact forcibly compresses the tissues against the subjacent bone and displaces the fat filling the interstices of the dense superficial fascia, into the surrounding meshes; here a limited barrier is formed, which, in consequence of inflammatory action, soon becomes firm, closely simulating a ring of bone. Blood and serum fill the space and form a blood-tumor.] I have noticed it frequently in the examination of chronic abscesses in various parts of the body, such as the buttock, arm, or knee. Blood thus effused may slowly increase, from the fact of the vessel remaining open, and bleeding subcutaneously; or the bleeding may cease, when changes commence calculated to remove the fluid. If, at the expiration of some weeks, an opening be made through the skin (a practice by no means generally to be recommended), a thick brownish-black fluid escapes, composed of blood-discs, albumen, and water. The absorbent vessels seem to remove the greater part of the fluid material, and either to remove, or to deprive of its natural properties, the coagulating element of the blood. If, under the circumstances of an injury, coagulation should take place—an event which must happen speedily, and before the absorbent vessels have had time to act on the blood, or else not at all—the clot acts as a foreign body, and will excite, especially in persons of unhealthy constitution, inflammation and suppuration, under which processes it will be discharged.

In these cases we again witness from time to time the action of causes which retard the absorption of blood. Let the patient pursue his usual habits, and take the customary amount of stimulants; the integument covering the swelling becomes hot and puffy, and the blood beneath either remains the same, or even increases in quantity. Let the patient adopt another course, namely, keep himself quiet, avoid stimulants, be moderate in his diet, and keep the bowels open, and the swelling, which was enlarging, first becomes stationary, and then disappears.

A boy aged seven was struck, July 1, 1838, on the right temple, towards the outer angle of the eye, by a stone, which was thrown at him by another boy in anger. A small wound was inflicted, which speedily healed; there was scarcely any bleeding at the time. The lad pursued his usual habits, and a fortnight after the accident, found his head heavy and uneasy, although free from pain. The mother detected, in the situation of the cicatrix of the wound, a soft swelling, which increased in size until he was brought to St. Bartholomew's Hospital, where he was admitted July 19. There was a large, fluctuating, and irregular swelling, caused by the elevation of the integument by fluid. The sensation of "depression of bone" was communicated to the fingers. He was ordered aperient pills, and a cold lotion was applied to the head. On the 23d of the month, no change being noticed, a puncture was made, when about four ounces of dark-colored fluid blood escaped. The peculiar sensation resembling depression of bone was yet more evident. In three days he was convalescent, and discharged well towards the end of the month.

After very severe injuries involving fracture of the skull and injury to the brain, blood-stains and ecchymoses about the eyes remain unchanged for many days, or even weeks. Their existence is merged in the greater injury, and they are only important as a signification, by their persistence in doubtful cases, of the existence of some serious complications. After severe injuries to the great nervous centres, all vital processes are depressed and in part suspended.

We read of bruises, wounds, and other injuries of the frontal, and sometimes of the infra-orbital nerve, followed by amaurosis; and authors have endeavored to explain the connection between the two. I have seen both nerves divided, and otherwise injured; the frontal nerve frequently, in cases of surgical operation and accident,

[1] Agnew's Surgery, vol. i., p. 256.

and no instance ever came before my observation in which the injury to the nerve seemed to exert the least effect upon the organs of vision. A severe blow with a stick or sword upon the brow may be followed by immediate blindness, whether it divide the frontal nerve or not. But, then, the loss of vision is due to concussion of the retina, to rupture of the minute blood-vessels which ramify in that delicate nerve-layer, or to some other internal disorganization; and we must in this way explain the case which Petit brought before the Academy of Surgery, namely, that of an officer who became completely amaurotic in consequence of a sword-wound in the eyebrow. To this same opinion the late Mr. Tyrrell inclined; he denied the existence of sympathy productive of such serious results between the fifth and the optic nerves, and referred the loss of vision to concussion of the retina. In the same way, I question the accuracy of the observation by Mr. Wardrop, that a partial, but not a complete division of the frontal nerve will sometimes produce amaurosis; and likewise the advantages of the method of treatment founded on that opinion, namely, to cut down and completely divide the nerve in question. "I have met," says Dr. Hennen, "with one or two cases of amaurosis from wounds of the supra-orbital nerve; the perfect division of the nerve produced no alleviation of the complaint; but after some time, the eye partially recovered." "When defective vision follows a wound in the forehead," said the late Mr. Guthrie, "the only hope of relief, that we are at present acquainted with, lies in a free incision down to the bone, in the direction of the original wound; and even of the efficacy of this, I am sorry I cannot offer testimony from my own practice, *having failed in every case in which I tried it.*"[1] It is not easy to explain Vicq d'Azyr's experiments upon this subject. He laid bare, in a variety of animals, the frontal and superciliary branches of the fifth pair; he bruised and tore the exposed nerves, and convinced himself that this was speedily followed by blindness.[2] Now I divided the frontal nerve in two rabbits, in the month of February, 1839, in order to verify the former experiments. After bruising and cutting the nerves in more places than one, I allowed the wounded parts to heal. No sensible effect was produced in the vision of the animals. In the summer of 1857, I assisted Sir W. Lawrence in the operation of dividing the infra-orbital nerve in a lady, of middle age, who had been a most severe sufferer from neuralgia. The sight remained the same, although the severment of the nerve-fibres in that situation is attended with a considerable amount of bruising.

But the use of the ophthalmoscope renders the diagnosis in those cases far more accurate and certain than in former times; and for the mode of its application, the reader is referred to the essay on DISEASES OF THE EYE.

A divided nerve unites as readily as any other organized structure; and the usual functions are restored when the connecting processes are completed. The nerve-fibrils pass through the effused fluid, and adapt themselves accordingly. Mr. Quekett, of the Royal College of Surgeons, possessed a specimen showing this process of union; and of its completeness we have abundant illustrations in cases of accident to other than the frontal nerve. The external popliteal nerve is sometimes cut through by the surgeon, in the division of the tendon of the biceps flexor cruris. The loss of sensation and motion, which is the immediate result, to the great dismay of the patient, is after some weeks completely restored.

WOUNDS.

The treatment of wounds of the face consists, as in the case of wounds in other parts of the body, in holding the divided surfaces in apposition until nature has had time to throw out a new connecting medium; only, in the face, more than usual care is required to maintain the parts in their exact normal relation. Let us imagine the unpleasing effect produced by the imperfect adjustment of a divided eyebrow. Sir W. Lawrence once had to reopen a healed but badly-adjusted wound in this situation, in consequence of the unpleasant expression it conveyed to the features, and to cause it to reunite in a more accurate manner. Wounds of the eyelids, particularly when attended with loss of substance, may be followed by eversion or ectropium; and wounds of the nose and lips, badly treated, may injuriously affect the functions of the organs of which they are the instruments. I cannot understand the "immediate union" of Dr. Macartney; that is to say, "that the divided bloodvessels and nerves are brought into perfect contact, so that union takes place in a few hours; and as no intermediate substance exists in a wound so healed, no mark or cicatrix is left behind." The union of divided surfaces, without the assistance of a new connecting medium, appears to me an impossibility. But the surfaces of a wound may be so accurately brought together, that the thinnest possible layer of connecting material may suffice for the reunion of the cut parts; in which case no evident cicatrix will follow. In all cases therefore,

[1] Lectures on the Op. Surg. of the Eye, p. 102, 1823.

[2] Journal Complémentaire des Scien. Méd., vol. xliv., p. 201, 1832.

whether we employ plasters or sutures, our endeavor should be to hold the wound together until the natural union by effused lymph is sufficiently strong to dispense with artificial assistance.

[When hemorrhage from wounded vessels of the face is so profuse as to make the use of ligatures necessary, preference should be given to the carbolized catgut. It is well known to every unprejudiced surgeon who has had experience with these ligatures, that when they are used they do not interfere in the slightest degree with the healing processes.

The writer was called upon a few weeks since to treat an extensive incised wound of the lower part of the face, in which the facial artery and some of its branches were cut. To check the bleeding it was found necessary to use nine catgut ligatures: these were cut off short and the wound accurately approximated by several points of silver sutures. On the third day the sutures were removed, and firm union of the wound was found throughout its entire extent.

The loops of catgut in this case must have been either absorbed or otherwise disposed of in the tissues, for the union remained perfect. Such a result in so short a time would have been impossible had silk or hempen ligatures been employed.]

A clean cut on the forehead does not always need a suture; the necessity depends upon the gaping of the wound. If, as is commonly the case, the edges keep in apposition, a few strips of plaster are all that is required: and let not the surgeon remove them for some days, unless heat and swelling supervene. Nothing interferes so much with processes of repair as constant changes of plaster, washings, and examination; a wound heals readily under an incrustation, or a hardened clot of blood, if left to pursue its own course, in a healthy subject. The practice of the antiseptic treatment of wounds is here wholly uncalled for. The great point is to surround the patient with unvitiated air.

Wounds involving the eyebrow should always be united by a few points of the interrupted suture, care being taken that the cut edges are quite clean. The shape of the eyebrow should be considered, and the first suture should be so inserted as to prevent any irregularity in that important feature. As regards division of the upper eyelid, an accident comparatively rare, no definite rule can be laid down. The part may be united by suture to the integument of the brow, if torn or separated therefrom; but the whole thickness of a divided eyelid should not be transfixed by a suture, one part of which must of necessity press upon and irritate the globe of the eye. Generally speaking, the prominent and convex globe forms an excellent support to the divided lid, and a few thin narrow strips of plaster, passing transversely as regards the wound, covered by others which, applied vertically, strap the lid down, and prevent the patient opening the eye for a few days, are quite sufficient. In some severe cases, the swelling about the brow and cheek has been so great, that the lids have remained closed for several days; under such circumstances, the application of a damp cloth is all that is needed. Hare-lip pins are out of place in wounds of the eyebrow; the desired end can be obtained, doubtless, by their means; but the proceeding is unnecessarily irksome, and possesses no advantages over the suture. The metallic suture should be used, if the surgeon happen to possess the necessary material; but for all usual emergencies a small needle, slightly curved towards the point, armed with a fine round silken ligature, will be found sufficient. There is no necessity for the patient to have the face constantly covered with a wet cloth. He may consult his own feelings; and the surgeon may remember that the process of union goes on most favorably under the thin dry line of blood marking the well-adjusted wound.

A vertical wound of the upper eyelid, passing through its whole thickness, the edges of which have cicatrized separately, leads to a deformity which has been termed *coloboma*. At the present time, however, this word is generally used to designate the congenital variety of the deformity. It may be rectified by an operation similar to that for hare-lip, excepting the employment of a hare-lip pin. A sufficient amount of union may be maintained by fine sutures, and the closure of the lid over the globe of the eye effected by strips of plaster. "I have seen a case," observed Sir W. Lawrence, "in which a horizontal wound of the upper lid having been neglected, a sort of button-hole was formed from the edges not having been kept in apposition; what was worse, accretion of the conjunctival surface of the palpebra to the globe had taken place, and the lid hung so much over the globe as to render the eye almost useless." I have seen the same under circumstances of disease, where ulceration of the eyebrow and upper lid has ensued from syphilitic periostitis of the frontal bone. In such cases, the amount of disease still going on, or liable to return, renders operative interference unadvisable.

As regards wounds of the external ear or of the nose, the rule is absolute in surgery, that, whatever be the amount of injury, the parts should be carefully cleaned, replaced, and held in apposition by a few sutures and fine strips of plaster. Results which surprise even the experienced are thus obtained in the most unpromising

cases; and the deformity is comparatively inconsiderable.

We read of cases of the division of Stenon's or of Wharton's duct, of the establishment of a salivary fistula, and of the necessity of a plastic operation. The subject will be more fully discussed in the article on PLASTIC SURGERY. But I have never seen a simple wound of the face followed by the accident here referred to. Monro states that the duct has been wounded by the surgeon's lancet; and Desault, that it has been ruptured by a blow; and the latter gives minute directions, which are commonly quoted in surgical works, as to the mode in which the continuity of the canal is to be reëstablished and maintained. He recommends the introduction of a seton through the canula of a small hydrocele trocar into the mouth; the wound to be dressed daily, lint and a compress being applied to the cheek. Those who wish the details of this operation may consult Œuvres Chir. de Desault, par Bichat, t. ii., p. 221. I have had no experience of the use of the actual cautery, nor of the employment of a wire heated by an electric battery in these cases, although such means have proved of great avail in the closure of fistulæ in other situations. Rodolfi gives the particulars of a case in which he closed the opening by means of collodion.[1]

[Some cases of salivary fistulæ, especially those arising from wounds of the parotid gland, may be cured by cauterizing the track of the fistula with a pointed stick of nitrate of silver. If, however, the track of the sinus be tortuous, injections of strong solution of nitrate of silver or sulphate of copper may succeed in closing it.

When a wound involves the parotid duct and the communication with the mouth becomes obliterated, a true salivary fistula is the result. To cure this condition the late Professor Horner devised an operation which consists in first exposing the duct by an incision through the integument of the cheek, then cutting out a small section of tissue by means of a punch introduced into the incision and a wooden spatula placed against the inner surface of the cheek. The external wound is to be immediately closed by sutures, with a view to securing quick union.

Another plan of accomplishing the same object is by the employment of the thread-seton. This consists in including a small mass of the tissue intervening between the bottom of the fistula and the cavity of the mouth in a loop of ligature, the ends of which are carried out of the angle of the mouth and secured to the cheek by a strip of plaster.]

[1] Gazz. Lomb., iii., 1854.

Wounds involving the whole thickness of the lip are usually united by the hare-lip pin and sutures. In all cases it is important to preserve the line of red margin to the lip; and this is best effected by a very fine needle and suture. But the metallic suture introduced by means of Simpson's grooved needle possesses the advantage of exciting so little irritation, that four or five days may elapse without any surgical interference. The wound should then be held together by fine strips of plaster passing round the entire head, by which the traction on the newly-formed material is prevented. An instrument for pressing together the cheeks has been invented for the same purpose. Collodion is rarely used as an application in wounds of the face; it drags too forcibly and unequally on the surrounding structures, and presses the blood from the capillary vessels, by which the process of repair is retarded.

[The above objections to the use of collodion in the treatment of wounds of the face do not apply to the flexible collodion or the glycerized collodion made according to the directions of the U. S. Pharmacopœia.

The edge of a wound may be firmly held in accurate apposition by strips of tarletan or Donna Maria gauze, secured by either of the two varieties of flexible collodion; and the wound itself may be hermetically sealed by a film impermeable to water, by spreading it over with collodion.]

Foreign bodies are occasionally introduced, more particularly by children, into the ear or nose. They should be removed from both situations, provided this end can be accomplished without pain to the patient, and with ease to the surgeon. But when it is remembered that, if left alone, the foreign body generally becomes loosened, and escapes without surgical interference of any kind, we have a very strong argument against the adoption of any means involving suffering. No cases similar to those related by Acrel in 1778, and by Morgagni and Valsalva, of worms making their appearance in the auditory passage, have been noticed of late years; surgeons have not been called upon to treat convulsions dependent on such causes; and the practice of injecting the distilled water of St. John's-wort, in which mercury had been agitated, for the purpose of destroying the worms which remained, has gradually fallen into merited disrepute.

Mr. Samuel Cooper saw the case of a child aged two years and a half, into one of whose ears a pebble, and into the other a French bean, had been pushed by another child, and remained there ten months, causing complete deafness and extreme suffering. These bodies were removed by the forcible injection of tepid

water and the use of a bent probe. In all probability the meatus had become widened.

I saw, in August, 1859, a child about three years old, at Epping (a patient of Mr. Duncan Macnab, of that town), into whose ear a small oblong pebble had been introduced, just of sufficient size to occupy the auditory passage. There was no difficulty in touching and even moving the stone, but in every attempt to seize it with a pair of forceps the ends of the blades slipped off and jerked the body farther towards the tympanum; and the introduction of a bent probe, or thin piece of metal, was impossible, owing to the narrowness of the passage. Mr. Macnab determined, in the absence of urgent symptoms, to wait and see what course nature would pursue. The following day, amidst a considerable quantity of thick puriform discharge, the pebble presented itself at the external orifice, whence it was easily and without pain extracted by a bent probe, and the little patient had no bad symptoms.

We should remember that the auditory passage is widest at the external orifice; then it narrows somewhat, and becomes wider again towards the membrana tympani. Thus foreign bodies, particularly when round or oval, can with difficulty be handled when they have passed through the contracted part of the tube. Singular stories are told of the effects produced by their long residence in the ear. Hildanus affirms that he cured a young girl of epilepsy by accidentally removing from the ear a foreign body which had been introduced seven years before, and had been quite forgotten! Small forceps and scoops are made to assist the surgeon. One of the most useful instruments is a long flat steel probe, the end of which can be made to bend to a right angle by a screw fixed at the handle.

Directions are given that such instruments should be introduced along the upper rather than the under wall of the meatus auditorius; that when the handle is raised so as to bring the end of the instrument over the foreign body, the point may recede from the membrana tympani, which is oblique in its direction from above downwards and inwards. It is unnecessary to condemn the unscientific suggestion of Duverney, namely, to make an incision behind the ear for the purpose of gaining space, for it must obviously be on the outside of the extraneous substance. Moreover, the cartilaginous external ear is a part on which the performance of a surgical operation is productive of the most severe pain. I remember the removal of a large part of the external ear, by Sir W. Lawrence, at St. Bartholomew's Hospital, from a man, the subject of chimney-sweep's cancer; and the patient, though rendered unconscious by the administration of chloroform, struggled so convulsively and uttered such loud cries as to attract the observation of those present. The great danger arising from the presence of a foreign body in the ear, is, that it should excite ulceration of the membrana tympani, and, falling into the middle ear, produce by its presence inflammation of the temporal bone. The compact structure of the petrous portion of the bone is ill able to withstand morbid processes; it soon dies, and sets up inflammation in the neighboring substance of the brain. The patient, after undergoing agonizing suffering, dies, laboring under cerebral symptoms; and upon examination after death an abscess is found, not uncommonly in the cerebellum, containing a greenish-colored matter, occasionally fetid, and surrounded by ragged and discolored brain-substance. For such an occurrence we have but limited means of treatment. We read of cases in which paralysis of the arm or leg suddenly supervenes, of the occurrence of delirium or coma; and pathological investigation shows that the sinuses, namely, the longitudinal, lateral, and petrosal, may be full of pus and lymph, proving that the patient has been attacked by intracranial phlebitis, as well as by disease of the brain itself. (Vide DISEASES OF THE EAR.)

[Lowenberg has reported an ingenious and perfectly safe plan which he resorted to to remove a foreign body from the ear. He applied the point of a small brush dipped in glue, in contact with the body in the meatus, and allowed the glue to harden, when he removed the brush and the body together.]

Foreign bodies introduced into the nose cannot excite the same dangers as in the former situation. They may in general be readily removed, either with the polypus-forceps or the scoop; the only danger attending the operation is that of breaking the spongy bones, or of pushing the substance backwards into the pharynx. Let it be remembered that, in children especially, there is no cause for anxiety or haste; the extraneous body will work its own way out, the surrounding parts receding so as to widen the passage by which it entered.

I was once consulted by a patient suffering from discharge from the nose, and found that the end of a style introduced some years ago down the lachrymal canal, but covered by the integuments of the face, projected into the inferior meatus. The removal of the instrument relieved the patient. A young man consulted Sir W. Lawrence in consequence of his suffering from discharge from the left nostril, accompanied with enlargement of the corresponding superior maxillary bone, which was soft and yielding. A probe introduced into the socket of the second molar tooth passed readily into the antrum, and allowed the escape of some thin sero-purulent fluid. In the course of a few weeks a small bit of lint escaped from the antrum through the socket of the tooth,

the discharge from the nose ceased, the cheek regained its normal size, and the man recovered. It turned out that the lint had been used, steeped in laudanum, for plugging the socket and relieving a temporary attack of face-ache.

The presence of a foreign body in the nostril may become the cause of ozæna, and lead to the secretion of a fetid puriform discharge; and attention has lately been directed to this subject by some of the surgeons of St. George's Hospital, who have pointed out the propriety in doubtful cases of careful examination, under chloroform [or ether], of the affected part.

In September, 1859, two little boys, between six and seven years of age, came under the care of Mr. Prescott Hewett. The first was said to have passed a plum-stone up the nose, and the event was supposed to have taken place a year previously. On examination, some foreign substance could be recognized, with the probe, high up in the nostril, and wedged against the spongy bones. It was impossible to deal with it until chloroform had been given, and this having been done, a long screw (more than an inch in length) was with some difficulty extracted. The child soon recovered. The other had been under the care of various practitioners for the last three years, on account of "discharge from the nose, ozæna," etc., but without any suspicion entertained of a foreign body being present. On examination, Mr. Hewett recognized, at the top of the nostril, a black colored substance, which seemed hardly like a portion of the natural tissues. The child was therefore put under the influence of chloroform, and a small black button (such as is used on boots) was extracted. The ozæna and discharge from the nose soon disappeared.[1] Another case has been described, in which a piece of wood-shaving was removed under similar circumstances.

[Foreign bodies in some cases may be loosened and washed out of the nose by means of Thudichum's douche. Of course the stream of water, which ought to contain a little common salt or chlorate of potassium, should be directed into the opposite nostril. This means, if not successful the first time, may be repeated at intervals, and in those cases in which ulceration has been excited by the presence of the body, the douche will serve a double purpose, to remove the accumulated secretion and to displace the offending body.]

For the treatment of the scars resulting from burns and scalds of the face, vide PLASTIC SURGERY. I may here remark, that, after the application of heat in any form to the integument, the great point to ascertain is, whether the entire thickness of the skin has been destroyed. If only the superficial layer has been disorganized, repair goes on, without subsequent contraction, by means of a number of small florid and well-formed granulations. If, however, the whole thickness of the integument is involved, then to a certainty contraction will follow. The eyelid will be drawn downwards, producing ectropium; the nares may be narrowed and twisted; the mouth drawn downwards and to one side, exposing the teeth and jaw. The features cease to be in harmony, and the teeth become horizontal. Surgical skill is often in vain invoked to arrest the contraction; it goes on steadily and slowly, however we may arrange the plasters and dressings, or in whatever position the patient may be placed. It is in general after a lapse of years that relief from the deformity is sought; and then the disappointment attending plastic operations, or partial divisions of the contracted bands, has been too generally experienced to need comment. I would call especial attention to the treatment of these contractions by slow, gradual extension, the advantages of which proceeding merit more general attention: the contractile material of the cicatrix becomes slowly absorbed, and when once absorbed is not reproduced; the hard and puckered skin becomes soft and yielding, though never like healthy integument; and results are ultimately attained which surpass expectation. The objection to this practice, that it is slow and involves a treatment of many months, is not tenable, for the treatment of wounds made in the performance of plastic operations on cicatrices is very frequently more tedious still; and then it must be remembered, that after the wound has healed, a process of contraction goes on again in every part allied in its nature to a cicatrix, and in many cases the surgical operation has to be repeated.

Cases occasionally present themselves in which the cheek becomes adherent to the gums, in consequence of sloughing of the lining membrane, and subsequent granulation and union of the adjacent surfaces. The movements of the mouth are always so much impaired that the power of mastication is lessened; and it occasionally happens that the teeth are so firmly clenched, that there is difficulty in giving to the patient the necessary nutriment.

I saw, in 1845, a lady to whom this accident had occurred, after profuse salivation, directed for the purpose of relieving her from an attack of psoriasis. The soreness of the mouth caused by the mercury was aggravated by the presence of some carious teeth, which the surgeon refused to remove. A very strong band of adhesion formed, which was twice divided by another surgeon; the relief thus afforded was temporary, and the closure of the mouth recurred in the course of a few weeks. About the same time I saw a boy, all of whose teeth were sound; but in whom sloughing of the mucous membrane of the cheek had taken

[1] Brit. Med. Journal, Sept. 24, 1859.

place during the course of some eruptive disorder. Two cases very similar to the last have been lately treated in St. Bartholomew's Hospital. In the first patient, a young girl of fifteen years, a single band of considerable thickness had formed on the right side of the mouth. It was extirpated by operation down to the healthy structures; but, as cicatrization proceeded, the mouth would have closed again, had not small ivory wedges been introduced between the teeth, and retained there by night as well as by day. In the second, a boy aged ten, the adhesions were more general: no operation was performed; and a limited amount of benefit was obtained by the employment of the ivory wedges. There was a case of contraction of the mouth in a man, a patient at the Royal Orthopædic Hospital (in 1859), who had been a sufferer from rheumatic disease of the articulation of the lower jaw. The tissues round the articulation were hard and unyielding, and scarcely permitted the least separation of the teeth. Considerable relief was obtained by slow extension.

In all these cases, whatever may be the primary cause, the rule to observe is, to avoid as much as possible the use of the knife. Division of the morbid parts must be followed, however skilfully the operation is performed, by the formation of a fresh cicatrix, in which the tendency to contraction will exist to the same extent as in the original cicatrix. Indeed, the mouth becomes stiff during the night while the patient sleeps, unless the jaws be kept artificially open. The treatment by the introduction of wedges of gradually increasing size is founded on this recognized principle, that pressure, however gentle, will, if steadily and unremittingly persevered in, gradually overcome the most powerful resistance; and experience shows us that, under such a process, the strongest bands of adhesions become elongated, absorption removing that part of their tissue in which resides the tendency to recontract. Consequently, when the mouth has once been opened by such a plan of proceeding, it is found on examination that the newly-formed tissue has lost its hardness, and that the advantages which the patient has derived are permanent.

Hemorrhage from the ears, after injury, is commonly regarded as an indication of fractured skull; and such indeed it is, provided the flow of blood be copious. But there are other cases in which the hemorrhage is not considerable, and seems to proceed from the lining membrane of the external ear, without the more serious complication.

A boy was admitted into St. Bartholomew's Hospital, December 14th, 1843, having fallen on his head from a pillar six feet in height. His parents stated that he was taken up insensible blood flowing from both mouth and ears. His shirt was stained with blood. At the time of his admission he was just able to speak and answer questions. The head was shaved, and a cold lotion was applied; no bad symptoms supervened, and he was discharged well within a month.

Such cases are by no means uncommon in hospital practice, and may, with a little care, be readily distinguished from those of more serious character, in which the flow of blood depends on fractured base of the skull, and laceration of some of the venous sinuses. (Vide INJURIES OF THE HEAD.)

[A rare case of injury to the face, resulting in separation of the nasal bones from their connections, was recently admitted into Bellevue Hospital, N. Y.[1] The nasal bones were separated from the cartilages below and the frontal bone above, and the whole organ displaced laterally. The deformity was corrected by manipulation, and the normal relation of the parts maintained till union occurred, by a mould of lint soaked in plaster of Paris and held in position by strips of adhesive plaster.]

FRACTURES.

Fractures of the ossa nasi are not uncommon, and are usually attended with depression, but swelling and ecchymosis often render the diagnosis at the time of the accident difficult. In the Museum of St. Bartholomew's Hospital, there is a preparation showing the "union of a transverse fracture of the ossa nasi a short distance above their lower border."[2] When replacement of the depressed portions is practicable, the surgeon must introduce into the nostril some such instrument as a female catheter, or a pair of dressing-forceps, and apply pressure in the right direction. He is recommended to plug the nostril, when the tendency to displacement remains; but I do not approve, as a rule, of distending the nostril with a foreign body. It was remarked by Sir C. Bell, that no tubes can be employed so as to support the broken bones; and when these have been replaced, they will not readily change their position, as they are acted on by no muscles. Hemorrhage may be profuse for a time, but usually ceases spontaneously, or upon the application of cold. Plugging the nostril should not be resorted to except in cases of severe displacement of the bone, for it causes the patient great discomfort, and not uncommonly fails to effect the purpose for which it is used. [Dr. Lewis D. Mason,[3] of New York, by a series of experiments on the cadaver, has been led to believe that, in

[1] New York Med. Jour., vol. xxi., p. 610, 1875.
[2] Ser. iii., prep. 75.
[3] Annals of the Anatomical and Surgical Soc., Brooklyn, Mar., 1880.]

fractures of the nasal bones with depression of the fragments, the nasal processes of the superior maxillary bones are likewise broken. To overcome the tendency to depression of the fragments in such cases, Dr. Mason has suggested an ingenious device, the value of which has been recently tested with success by Dr. C. B. Nancrede, of Philadelphia. The plan consists in the introduction of a medium-sized three-cornered surgical needle, gilded or nickel-plated, through the lines of fracture of the nasal processes of the superior maxillary bones, after the depressed fragments have been elevated to their normal position. The dressing is completed by a strip of rubber gently stretched over the bridge of the nose and secured to the ends of the needle. At the expiration of a week or ten days the needle may be safely removed, for, by that time there will be sufficient consolidation to hold the fragments in position. Mr. Adams,[1] in the treatment of fracture of the nose, resorts to an ingenious method for correcting deformities of the cartilaginous septum and supporting the lower margin of the nasal bones. With flat-bladed forceps he forcibly straightens the nasal septum when bent, and raises the lower margin of the nasal bones. By means of an ivory clamp he preserves the line of the cartilaginous septum with the bony, and in addition, he uses a nasal truss to retain the parts in the improved position. Mr. Adams has succeeded in overcoming deformities of the nose, consequent upon injuries received eight or ten years previously, by this plan.] Cases occur in which the septum nasi, together with the crista galli and cribriform plate of the ethmoid bone, are driven upwards to the skull; and there may be injury to the brain and escape of cerebral matter. The fracture of the facial bones is here comparatively unimportant; and the injury must be regarded as a variety of fracture of the base of the skull, of which the rules of treatment are given in the essay on INJURIES OF THE HEAD. In the same way, injuries of the lachrymal bone involving the nasal duct, will be considered under the head of INJURIES OF THE EYE. The eye may be bruised by the same injury which has broken the nasal bones, but it is rarely affected secondarily by inflammatory disturbance.

Mr. South relates the case of a man who was struck on the face with the handle of a crane, and in whom all the bones were separated and loosened, "feeling like beans in a bag." The bones may be crushed by the passage of a bullet, or by a fall on the face from a great height. The chances of recovery depend upon the amount of injury which has been sustained by the brain. We have no means of setting or adjusting the broken bones, and we must be content with general treatment. The teeth are commonly loosened, or completely detached. In the former case it should be remembered that they may again become firm, and should be left *in situ*. A completely detached tooth replaced in the socket may, it is true, contract some adhesion to the gum; but sooner or later it acts as a foreign body, and, after exciting irritation, falls out, to the great comfort of the patient.

Hyrtl remarks, that an observation by Pétrequin and Bouchacourt on injuries in this region is of importance in a medico-legal point of view; namely, that wounds of the face caused by the violent action of blunt instruments have often the same appearance as if inflicted by the sharp cutting edge of a knife. The sharp border of the superior maxillary and malar bones, or the edges of the teeth, will, when a blunt body presses against them, cut through the skin and subjacent soft parts, and cause an injury closely resembling an ordinary incised wound.

Middeldorpf[1] relates a case of fracture of the upper jaw and malar bone, together with fracture of the vomer and ethmoid, accompanying fracture of the lower jaw, from a fall. He points out the possibility of a fracture of the upper jaw in consequence of a blow upon the chin. The symptoms, resembling those of fracture of the base of the skull, which sometimes accompany fracture of the malar bone, have been already referred to under INJURIES OF THE HEAD, p. 8; and some further observations on the treatment will be found at p. 433.

[When great force is received on the prominence of the cheek the body of the malar bone is less often fractured than the zygomatic process. Professor Agnew,[2] by experiments on the cadaver, proved that force applied to the malar prominence fractured not only the zygomatic process, but also the floor of the orbit, before the body of the malar was broken. In every experiment the line of fracture of the orbital plate terminated in the spheno-maxillary fissure. When there is depression of the malar bone Hamilton[3] suggests that the bone be raised into position by the thumb carried up under the zygomatic process in the mouth. If this manipulation fail or be not available, the bone should be pierced by a screw elevator and lifted up to its normal position.]

[1] Med. Times and Gazette, Feb. 23d, 1878, p. 201.

[1] Beiträge zur Lehre von den Knochenbrüchen, von Dr. A. Th. Middeldorpf, Breslau, 1853.

[2] Agnew's Surg., vol. i. p. 839.

[3] Hamilton on Fractures and Dislocations, 6th edition, p. 115.

Fractures of the lower jaw.—The lower jaw is the strongest of the bones of the face; the lower margin of its body is more prominent than the upper, which is composed of alveoli, and contains the teeth; the front surface is therefore oblique, from below upwards and backwards; and this obliquity becomes the more marked as the teeth drop out and the alveoli become absorbed in the processes common to old age. Indeed, in the jaw of a very old person, the mental foramen approaches the upper border of the bone. The rami are nearly perpendicular to the body in middle age, but in both very old and very young the direction is obliquely backwards, and approaches the horizontal. The strongest part is the symphysis, or that part where the two halves of the bone, separate in fœtal life, become coalesced in the course of development. In this immediate spot fracture rarely occurs, the bone usually giving way a short distance either to the right or the left, where it is thinner, in the space between the symphysis and the insertion of the masseter. In other cases, the fracture occurs at the angle, or in the ramus of the jaw, the coronoid process, or the condyle. The bone may be broken in more than one place; fracture may be combined with dislocation.

Bonn[1] gives an account of fracture combined with dislocation of the condyle of the lower jaw. There was a longitudinal fracture in the middle of the bone, and at the same time the right condyle was broken off from the neck, and dislocated forwards and inwards, where it lay united by callus, near to the foramen ovale (foramen maxillare posterius). The pointed upper extremity of the neck of the lower jaw articulated with the glenoid cavity, and the separated "head" with the lateral part of the tubercle of the temporal bone. There was motion in the joint. The same author mentions a case of fracture and dislocation of both condyles of the lower jaw. In a young man, who had had numerous other fractures, and who died five weeks after the accident, there was found, besides a longitudinal fracture of the middle of the bone, fracture and complete separation of both condyles, which were drawn forwards and inwards as in the preceding case, and fixed by callus, not far from the foramen ovale, on either side. On the left side, the articular or glenoid cavity was externally rough and uneven, and surrounded by a rough callous border; on the right side it was divided into two parts, of which the inner was hollowed out and smooth; the other uneven, and surrounded by a prominent callous ridge. The smooth cartilage-covered condyles were in contact with the cartilage-covered tubercle; the pointed upper extremity of the neck of the lower jaw, with the uneven surface of the glenoid cavity.

During the course of the year 1860, Mr. Holmes exhibited at the Pathological Society of London a specimen of a fractured portion of the neck of the lower jaw driven into the meatus auditorius externus. The accident was followed by serous discharge from the ear, simulating one of the symptoms of fracture of the petrous portion of the temporal bone at the base of the skull. The diagnosis of such cases is treated of under the head FRACTURES OF THE BASE OF THE SKULL. J. L. Petit mentions a case in which the bone was broken and the coronoid process completely denuded by a kick from a horse. Surgical writers have affirmed that serious cerebral and nervous symptoms may accompany fractures of the lower jaw; the former due to the amount of general violence which accompanied the local injury, the latter to laceration of the dental nerve in its course through the canal in the bone. The cerebral symptoms here referred to would be accidental, such as might accompany an injury to any other part of the body. The nerve-symptoms mentioned have not hitherto been witnessed by me in any such case; and Middeldorpf,[1] who has written on the subject, affirms that "laceration of the *nervus alveolaris* never excites dangerous complications." He records nine cases, and remarks that the displacement of the bony fragments is very often due to the direction of the force rather than to muscular action. It is unnecessary to remark upon the proposal of Fattori, to trepan the front wall of the jaw in cases of neuralgia, and to cut out or otherwise destroy the nerve.

Non-union, or even tardy union, of fractures of the lower jaw is very rare.

In the London Medical Repository for 1823, a case is noticed in which Dr. Physick cured such a case by means of a seton; and Ancelon relates the following case, in which the want of union appears to have been due to disease, perhaps partial necrosis, caused by the unnecessary amount of violence. A farrier presented himself with double fracture of the lower jaw, which had not been treated for five months. He had allowed a brother farrier of powerful frame to pull out a tooth for him, and in the act, the whole middle piece (*i.e.*, body) of the lower jaw was broken off a short distance in front of the masseters on either side. Upon examination, five months after the accident, M. Ancelon found the middle piece movable and producing crepitus on the opposed surfaces; the gum was thick and infiltrated, and the smell from the mouth almost unbearable. In consequence of some misunderstanding, nothing was then done, although the surgeon felt inclined to remove the whole

[1] A. Bonn, Descriptio thesauri ossium morbosorum Hoviani, Amstelædami, 1783–4; and ejusdem Tabulæ ossium morbosorum præcipue thesauri Hoviani. Ibid., 1785–8; or Gürlt, Beiträge zur pathol. Anat. der Gelenkkrankheiten, p. 122. Berlin, 1853.

[1] Beiträge zur Lehre von den Knochenbrüchen, von Dr. A. Th. Middeldorpf, p. 52. Breslau, 1853.

bone. A year and a day afterwards the man returned, wishing to get rid of his present suffering at any price. The left ramus of the jaw had been entirely separated and lost, the cicatrices by which it had come away being quite visible; a firm band was felt under the skin, passing down in the same situation to the middle piece of the jaw. The middle piece still contained one canine, two bicuspidate, and one molar, teeth. The right ramus remained in the socket, but the broken end was pulled up and pushed into the soft parts. The whole cheek was swollen; the angle of the jaw was carious and protruded through the skin. M. Ancelon removed the entire right ramus. The middle piece remained attached to the fibrous cord on the left side, and the patient regained sufficient power to masticate light food.[1]

When fracture occurs about the middle part or body of the lower jaw, the signs are sufficiently obvious. There is mobility of the parts, crepitus, and irregularity in the line of the teeth; the gums are torn and bleeding, the mouth is usually partly open, and the saliva dribbles away. It is commonly affirmed that, when the middle portion is broken on both sides of the symphysis, the detached fragment is drawn down by the depressor muscles of the lower jaw; such is sometimes the case, but the direction of the force applied must also be taken into consideration, as well as the inclination of the fractured surfaces. When fracture occurs in the ramus, or about the neck or coronoid process of the bone, the displacement is either inconsiderable, or else in such a situation as to be recognized with difficulty. The surgeon must then trust to careful examination and inquiry into the character of the accident, remembering that the presence of deepseated fixed pain, on examination, in a bone, after a severe injury, is a good diagnostic mark of fracture. There are some who speak of "compound" fracture of the jaw, where the gum is lacerated or the integument torn. The term, perhaps, is scarcely applicable in the sense in which it is used in cases of fracture of the long bones. In the latter the gravity of the complication consists in the laceration of the mass of soft parts, muscles as well as integument, covering a dense hard bone, such as the femur or humerus. Inflammation and suppuration are apt to ensue, producing exhausting discharges and hectic fever. In the former case, the laceration of the gum, or of the integument covering the jaw, is a matter of comparatively little moment; it adds nothing to the severity of the case; the soft parts unite readily enough, being a thin and highly-organized layer. The bone, also, more highly organized than the long bones, throws out, without effort, the proper material for repair. Beyond, therefore, the pain which such an accident causes, there is little ground for anxiety in ordinary cases, either to the surgeon or to the patient.

The treatment consists in maintaining the parts in steady apposition for from four to six weeks. During this period the patient must not attempt to chew solid food; he must live on soups, sopped bread, and other similar substances, which can be easily swallowed. He will not feel disposed to talk much, and, in so doing, should avoid moving the jaw. As a rule, he will content himself with merely expressing his wants. If the fracture be not attended with much violence to surrounding parts, there is no necessity to prescribe absolute rest; but, in cases where the soft structures are much lacerated and bruised, bed is the fittest place until swelling has entirely subsided.

Various substances are employed for the manufacture of a splint. That in most common use is gutta percha, which, when properly heated, adapts itself to the injured parts. The exact size and shape having been previously ascertained and determined, the gutta-percha should be cut accordingly, and then immersed in water heated to just below boiling-point. In the course of a very few minutes it becomes soft and perfectly pliant. It should then be removed from the water, and pressed for a moment between the folds of a dry towel. In this state, moderately dry and deprived of superfluous heat, it is to be put on the surface intended for support, and bound thereto by a roller. In the case of the jaw, the "four-tailed" bandage is of use in attaching the parts firmly to the head. The common causes of failure in the making of gutta-percha splints arise from the following circumstances. First, the water is not hot enough; secondly, the accessory appliances are not quite ready at hand; and thirdly, the surgeon is not quick enough. The whole proceeding should occupy a very brief space. Unless the gutta-percha is properly heated, it does not adapt itself, and the support which it affords is imperfect. A preparation of vulcanized india-rubber, now much used by dentists for the construction of artificial palates, etc., is also applicable for the purpose now before us. Card-board, leather, or even the four-tailed calico bandage stiffened with starch, may be employed when other materials cannot be obtained.

[For the greater number of uncomplicated fractures of the lower jaw the bandage suggested by the late Dr. J. Rhea Barton has been found, in Philadelphia, to be the most useful. This bandage consists of a piece of muslin two inches wide and five yards long. In applying it the initial end is placed midway between the

[1] Double Fracture de la Machoire inférieure, Gaz. des Hôpit., 1854, p. 550.

occipital protuberance and mastoid process of the sound side, then the bandage is carried just below the occipital and parietal protuberances obliquely across the top of the head, down on the uninjured side of the face, beneath the chin, up on the injured side of the face and over the sum-

Fig. 139.

FIG. 139. Barton's bandage for fracture of the lower jaw.

mit of the head, crossing the other turn in the median line; from this point it is conducted under the parietal protuberance, near the initial extremity, and forward round in front of the chin back to the point from which the bandage first started. These turns are to be repeated in the same order of succession till the bandage is exhausted. In order that this dressing may

Fig. 140.

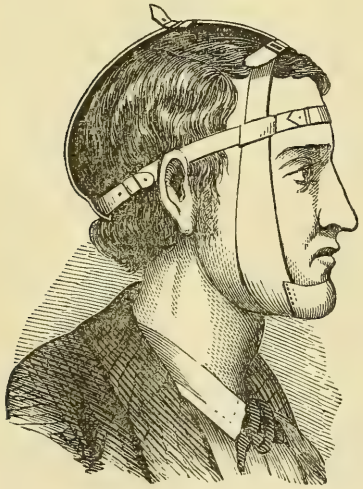


FIG. 140. Hamilton's bandage for fracture of the lower jaw.

act most efficiently, its vertical turns ought to pass from below upwards over the seat of fracture; thus applied they tend to press the fragments firmly against the upper jaw, which will serve as a splint. (FIG. 139.)

The accompanying woodcut (FIG. 140) represents an apparatus devised by Dr. F. H. Hamilton, of New York,[1] for treating fractures of the lower jaw. The portion of the apparatus that supports the chin is a leather strap, to which a piece of linen is attached, to go in front of the chin. This "maxillary" strap is buckled upon the top of the head. The other parts of the apparatus are two centre straps of linen webbing; one called the occipito-frontal, passes around the vault of the cranium and receives the tails of the maxillary on either temple, in loops; the other, the vertical, connects the occipital with the maxillary across the top of the head.]

When the injury has been considerable, as in the case of a gunshot wound, it may happen that no apparatus can be applied; union will go on equally well under a soft bread-and-water poultice, often renewed. The condition of the parts is such as to guarantee from the patient himself most perfect rest. The practice of tying the teeth together was known to Hippocrates. Cases occur in which it may be employed with some advantage; and then the surgeon should use the metallic in preference to the silken ligature, inasmuch as the latter is more apt to cut through the enamel of the teeth and to induce caries. When the teeth in the upper jaw are perfect, and can be applied to a set similarly perfect in the lower jaw, they serve as a useful splint, exerting counter-pressure to that caused by the gutta-percha.

[When the above methods fail to keep the fragments in their proper relative position, the extremities of the fragments may be drilled and wired together. If this plan be adopted the body of the bone, and not the alveolar process, should be drilled.]

The process of repair is not by provisional callus. A connecting material is poured forth from the vessels of the bone, in which ossification goes on in the usual way; the torn gum heals; teeth which have been only loosened regain their normal firmness; and the repair is usually perfect.

In cases of fracture about the ramus, condyle, or coronoid process, no more can be done than to keep the jaw quiet by means of the four-tailed bandage, either with or without any other splint, for the usually prescribed period. In the first situation, the masseter and internal pterygoid muscles prevent much displacement; in the second and third, the injured parts are beyond our reach. The detached condyle will be pulled forwards and inwards by the external pterygoid muscles, towards the base of the skull, near the foramen

[1 Fractures and Dislocations, Hamilton, 6th edit., p. 144.]

ovale, as described in the cases already recorded. The coronoid process may suffer some displacement by the action of the temporal muscle, but this may be inconsiderable, in consequence of the great extent of the insertion of the muscle, which reaches near to the last molar tooth. In all these cases an examination by the mouth may assist in our diagnosis.

Mr. James Salter, of Guy's Hospital, has adopted a useful mode of treatment in cases of fracture of the upper jaw. He prepares a gold plate to fit the interior of the mouth, so as to hold the displaced portions of bone as much as possible in position, thus far acting in every sense as a splint; but with the additional advantage that it is capable of repeated alterations from time to time, so as to force outwards inwardly projecting bone and teeth, as the patient can bear the pressure. He first takes an accurate model of the mouth, and upon this the plate or splint, whichever it may be called, is constructed, embracing some of the firm teeth. The plate is so framed as to exercise pressure only on the bone and teeth which are displaced.

The beneficial effect of this plan was proved in an interesting case recorded in the Lancet (June 16, 1860). A young gentleman, while playing at cricket, rushed forward with great impetuosity to catch the ball, when one of his companions, not perceiving him, and running forwards with a similar object, came into collision with him, and struck him a violent blow with his forehead on the upper jaw, immediately below the malar bone. There ensued a fracture of the maxilla, driving inwards the two right upper premolar teeth and the first molar, with their alveoli. The patient, by means of pressure gently maintained by the above-described splint, recovered completely in about six weeks; the displaced bone and teeth resuming their normal position.

Mr. Salter believes that the same principle may be adopted in fractures of the lower jaw. Any displacement that accompanies fracture of the superior maxilla is simply a passive condition; there are no muscles attached to the upper jaw which can derange or draw out of place the broken bone. With the lower jaw, however, the case is very different; the inferior maxilla is a floating bone, to which many powerful muscles are attached, and those connected with the rotating movement of the jaw —namely, the pterygoids—have a strong lateral antagonistic action. Destroy the integrity of the maxillary arch by fracture, and that antagonism ceases; the muscles on either side act independently, and draw the points to which they are attached more or less to the mesial line, and this it is which causes the overlapping of the fractured ends of the bone, often so obstinate. A plate or splint (for the lower jaw, Mr. Salter prefers an ivory one), carved to fit the interior of the arch of the particular jaw, with small crescentic excavations for the existing teeth, when placed in the mouth, restores the integrity of the arch for the time being. It may be worn without inconvenience long enough to allow osseous union of the fractured ends, preventing displacement the while.

It is asserted that in rabid horses fracture of the jaw occurs from muscular cramp alone.

The separation of splinters of bone, the treatment of abscesses, of necrosis, and other accidents common to fractures in general, must be conducted on the general principles of surgery.

Dislocations of the jaw.—The articulation of the lower jaw is the only one in the face which allows the head of the bone to escape from the articular cavity; the molar teeth of the upper and lower jaws are separated in mastication by the sliding forward of the condyles of the latter upon the eminentiæ articulares, while the adaptation of the bony surfaces is completed by the interarticular cartilage and its synovial membranes. The lower jaw slides forward upon the eminentiæ articulares in the act of masticating, of yawning, of laughing; and it is in one of these conditions in general that dislocation of the condyles under the zygomatic arch ensues, by the combined action of the masseters and internal pterygoid muscles. The temporal muscle drags the dislocated bone upwards.

The only direction in which this dislocation can happen is forwards. That in the backward direction is impossible, unless the osseous structure of the external ear is broken at the same time. Behind the condyle of the jaw lies a portion of the parotid gland and the mastoid process of the temporal bone. But displacement of either one or both condyles forward is of occasional occurrence. When recent, these accidents are attended with much pain. The mouth is open, and cannot be shut: an empty space is left before the ear in the natural situation of the condyles. The coronoid process may be felt through the cheek, or within the mouth, and there may be some flattening of the cheeks and temples. The saliva flows in great quantity. The relation of the teeth is altered. When only one condyle is dislocated, the incisor teeth incline to the right or left side; and this fact can be readily ascertained by careful examination. After a time these symptoms, if the dislocation be not reduced, are not so well marked; the patient gradually regains the power of articulation and of swallowing, and can retain the saliva; but the sense of great discomfort remains for a long time.

Hippocrates declared the accident mortal, if not reduced before the tenth day; but this is clearly an error. I have seen a patient four months after the accident, with dislocation of both condyles into the zygomatic fossæ. The patient had suffered and was still bearing much pain, but the symptoms were becoming more endurable, and the deformity was less apparent: an attempt to reduce the dislocation failed. In endeavoring to reduce a dislocation of the jaw, the surgeon cannot do better than follow the old rule, when the accident is recent: "Let him wrap some linen round his thumbs, to keep them from being hurt by the patient's teeth, and then introduce them into the mouth, as far as possible along the grinding teeth; at the same time he is to place his fingers under the chin and the base of the jaw, and while he depresses the molars with his thumbs he raises the chin with his fingers, by which means the condyles become disengaged from their situation under the zygoma; at which instant the muscles draw those parts so rapidly back into the articular cavities again, that the surgeon's thumbs might sometimes be hurt, did he not immediately move them outward between the cheek and the jaw."[1]

In the present day we use chloroform [or ether] in difficult cases, and have recourse to what Mr. Samuel Cooper calls the practice "of the ancients," namely, the insertion of two pieces of stick between the molar teeth, to be used as levers to depress the angles of the jaw, while the chin is raised by the hand or by a bandage. But even with this plan, usually successful, I have witnessed failures, and have myself failed to move the jaw in a case of old luxation, where the parts had adapted themselves to their new position. All dislocations of the jaw, from accident, should be reduced without delay.

[After the reduction, some form of bandage should be immediately applied that will keep the jaws closed, as in fracture of the lower maxilla, for a week or ten days. Unless this precaution be taken to insure rest during reparation of the ligaments, any movement of the jaw, as in talking, laughing, or chewing solid food, is liable to produce displacement.]

[1] Cooper's Surgical Dictionary, ed. 1830, p. 390.

INJURIES OF THE NECK.

WOUNDS.

By Arthur E. Durham.

Revised by Thomas G. Morton, M.D.

Wounds of the neck differ greatly in character, extent, and danger. The parts involved vary with the situation, direction, and depth of the wound, and also in some degree with the position of the head and neck at the time the injury is inflicted.

Accidental wounds of the neck are rare. They are more frequently punctured than incised, and are often somewhat contused. They result for the most part from falls upon sharp instruments or projecting points, and, as a rule, take a direction from below upwards and backwards.

Homicidal wounds of the neck are not uncommon.[1] They are generally incised, and often designedly simulate self-inflicted wounds. They seldom present any distinctive appearances. The stabs of the assassin in this region are usually directed from above downwards and towards the middle line.

[1] During the five years 1863–7, out of 612 murders and infanticides perpetrated in England by specified methods, 56 were accomplished by wounds of the neck. During the same period, out of a total number of 6696 suicides, 1235 were cases of cut throat. See Report of Registrar-General.

Suicidal wounds of the neck are comparatively common.[1] They are more common in this country than on the Continent.[2] These wounds are almost always incised, and are often lacerated, with more or less jagged edges. They are ordinarily made from left to right, and obliquely downwards or transversely across the throat. They seldom sink so deeply into the side of the neck as to reach the great vessels. The larger extent of the wound is, in most instances, on the left of the middle line; but this is not invariably the case, even though the right hand have been used.[3] Dieffenbach records the case of a young man who, having taken a razor in each hand, at the same moment cut across his neck from left to right, and from right to left. The wounds crossed one another over the larynx and trachea.[4] Most frequently the suicide makes but one gash. Sometimes, however, several wounds are inflicted before the fatal or final one is made. It is important to bear in mind that in consequence of its elasticity and mobility, the skin of the neck is easily thrown into folds and irregularly stretched; and thus several distinct cuts may be produced by a single stroke of the knife. The jagged and uneven appearances often presented by continuous wounds may be explained, to a certain extent, in the same manner.[5]

Punctured wounds are occasionally, though rarely, made in this region with suicidal intent. Lord Castlereagh, as is well known, destroyed himself by thrusting a penknife through his carotid artery. His method was attempted shortly afterwards by many would-be suicides, but in most instances without fatal result. Laugier[6] quotes the case of a lunatic, who, having penetrated his larynx by the point of a penknife, divided his thyroid cartilage into eight parts by turning the knife in various directions.

Suicidal wounds of the throat are most common among men of intemperate habits and broken health, who have passed the middle period of life. Sometimes they are inflicted during delirium; sometimes in fits of extreme despondency; sometimes, but not often, under the influence of privation or pain, or of distress of mind, delusion, or fear. Under any such circumstances the condition of the sufferer is unfavorable alike to recovery from the shock of the injury, and to subsequent repair of the damage sustained. Hence, these wounds are more likely to prove fatal than accidental or homicidal wounds of similar extent and severity. Hence also, special care and watchfulness are necessary in their treatment.

Wounds of the neck may be divided, for convenience of description, into those inflicted behind, those in the lateral regions, and those in front. Very often, however, the wound extends from one region to another.

1. *Wounds of the back of the neck* are less likely to prove dangerous to life than those in front. But it has been stated that they "often produce a palsied condition, and frequently a wasting of the lower limbs." "Wasting of the testicle and loss of the generative power" are also said to have been observed.[1] It is difficult to obtain good evidence in support of these statements, and it is probable that they apply only to cases in which the spinal canal has been penetrated.

M. Legouest saw in Algeria many cases in which very deep transverse wounds in the back of the neck had been made by the Arabs in their attempts to decapitate the soldiers who had fallen into their hands.[2] "The results were satisfactory, in spite of the size and thickness of the cicatrices;" and no such effects as those above alluded to appear to have been produced.

A deep wound in the upper part of this region, especially if made when the head is bent forwards, may penetrate between the occiput and atlas, or between the atlas and axis, and implicate the spinal cord or its membranes. There is no other part in which the cord can be so easily reached by a pointed or cutting instrument; nor is there any in which a wound of the cord is so likely to prove speedily fatal.

When the cord is wounded, sensation and the power of voluntary motion are instantly lost to an extent corresponding to the injury inflicted. A flow of cerebro-spinal fluid from the wound also occurs. This is often considerable, and sometimes continues for several days. Cases have happened in which the spinal membranes have been cut, but the cord has escaped almost intact. In such cases, an escape of cerebro-spinal fluid has been observed.

M. Laugier[3] refers to instances of infanticide accomplished by means of a long needle passed between the atlas and axis into the cord.

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[1] See previous note.

[2] The statistics of Brierre de Boismont (Du Suicide; Paris, 1856) show out of 4595 cases of suicide only 121 by cut throat.

[3] In St. George's Hospital Reports, 1866 (p. 368), reference is made to a recent example.

[4] Dieffenbach, Sur les Plaies du Cou. Archives générales, 2e série, t. vi., p. 237.

[5] For the medico-legal bearing of this point, see Casper, Sydenham Society's translation, vol. i., p. 129.

[6] Dictionnaire enc. (30 vol.), t. ix., p. 168.

[1] Chelius, System of Surgery, translated by South, vol. i., p. 437.

[2] L. Legouest, Traité de Chirurgie d'Armée, Paris, 1863, p. 407.

[3] Op. cit.

Wounds of the cord or its membranes in this region are extremely dangerous from their immediate effects, or from subsequent inflammation. But death is not invariably the result. Cases are on record in which life has been preserved, but in which there has been permanent paralysis of various parts.[1] Morgagni relates the instance of a young man who was stabbed in the neck, three fingers' breadth below the ear. He fell, deprived of sensation and motion in all parts of the body below the head; but at the end of four months he recovered the power of walking.[2]

A deep punctured wound behind and below the ear may implicate the vertebral artery. A case of this kind is recorded in which a false aneurism was formed; this led to the death of the patient some months after the injury.[3]

In the treatment of deep wounds of the back of the neck, especially if the muscles have been extensively divided, attention to position is of very great importance. The patient should lie upon one side, with his head in the same longitudinal plane as his body, but inclined somewhat backwards. The head should be supported and firmly fixed by means of sand-bags, or bandages, or some special apparatus; otherwise its natural tendency to fall forwards may cause separation of the lips of the wound, or even give rise to some degree of tension, or pressure upon the spinal cord. Sutures and adhesive plaster may be used, according to circumstances, to aid the closure of the wound; but in most cases "position" affords favorable cicatrization.

2. *Wounds in the lateral regions of the neck* are almost always either accidental or homicidal in origin. For the most part they are inflicted by the assassin's dagger, which too often is plunged with fatal effect into the root of the neck. Such wounds are very dangerous from their liability to implicate the great vessels and important nerves. Sometimes the upper part of the cavity of the chest is penetrated, and the lung wounded. Occasionally, the blood-vessels and nerves and other important structures escape in an almost marvellous manner; and recovery may take place, even though the lung has been wounded.

A case of this kind has recently been under the care of Mr. Birkett, in Guy's Hospital. A stab from above the clavicle implicated the lung; there was emphysema, but little or no bleeding. The patient made a good recovery.[4]

3. *Wounds of the front of the neck* may be made anywhere between the upper border of the sternum and the lower jaw. Sometimes they are mere abrasions of the skin. Sometimes they are superficial, implicating the subcutaneous structures as well as the skin. Sometimes they are deep, penetrating the air or food passages, or both, or even extending through all the soft parts down to the spinal column.

Superficial wounds in this region are not altogether free from danger. They are often attended by considerable hemorrhage. If the external jugular vein is wounded, death may ensue, either from loss of blood, or from entrance of air into the vein.[1]

In some cases diffused cellulitis occurs, and spreads rapidly. Sloughing may ensue, or pus may burrow in various directions, sometimes even extending into the anterior mediastinum. Wounds over the thyroid cartilage occasionally give rise to inflammatory œdema of the larynx and pharynx; and there may be difficulty of breathing, alteration of voice, and pain in swallowing, although the mucous membranes have not been injured.

In consequence of the elasticity of the skin, the laxity of the areolar tissue, and the action of the platysma myoides muscle, the edges of these wounds are often widely separated at first, and have a great tendency to roll inwards when attempts are made to bring them together. Hence arises, in part, the difficulty often met with in obtaining primary union. This difficulty is increased by the frequent movements to which the neck is liable. Accurate coaptation of the lips of the wound is best secured by a very fine continuous suture, or by many short stitches near to one another; these should be passed through the skin only, and so close to the edges that no portion can roll inwards. The elasticity of the skin and the action of the platysma may be counteracted by long strips of adhesive plaster applied obliquely across the neck, or parallel to the fibres of the platysma. Tension upon the wound and the general movements of the neck may be, to a great extent, prevented by supporting and fixing the head in proper position. Whatever pains, however, may be bestowed, it often happens that primary union does not take place; and the process of healing by granulation is but slow.

Deep incised wounds, which penetrate

[1] Longet, Anat. du Système nerveux, vol. i. Dictionnaire encyclopédique des Sciences médicales, t. vii., p. 70.

[2] Quoted in Diction. enc. (30 vol.), art. Cou.

[3] Archives générales, 2e série, t. v., p. 138.

[4] Lancet, September 4, 1869, p. 337. See also a remarkable case recorded by Gross, System of Surgery, vol. ii., p. 385. A young man was stabbed in the neck by a long, narrow knife. The œsophagus, trachea, and great vessels escaped. But the right upper extremity became immediately palsied. General recovery took place, but the paralysis remained.

[1] A remarkable case of sudden death from wound of the external jugular vein is recorded in the Boston Medical Magazine, vol. iii., p. 171.

into the air-passages, very generally implicate other important parts also. Such wounds are liable to be attended by certain dangers and complications more or less common to all, whatever their precise situation; and by others which vary with the particular structures involved.

Some idea as to the relative frequency with which the different portions of the air-tube are wounded, may be gathered from the following summary of 158 unselected cases, of which I have obtained particulars.

Situation of Wound.	Number of Cases.
Above the hyoid bone	11
Through the thyro-hyoid membrane .	45
Through the thyroid cartilage . . .	35
Through the crico-thyroid membrane, or cricoid cartilage	26
Into the trachea	41

The sources of danger, and after-complications common to most of these wounds, irrespective of their precise situation, are as follows:

1. Hemorrhage, arterial or venous, may prove fatal almost instantly, or very speedily and before assistance is at hand. Sometimes, after having completely ceased for a time, during syncope or from some other cause, it recurs to a serious extent. This is especially likely to happen when a small opening has been made into one or other of the great vessels. As a general rule, the great vessels escape in cases of suicidal cut throat. They owe their comparative immunity, in the first place, to their elasticity and mobility, and the consequent ease with which they are carried, as it were, with or before the knife; and in the second place, but not less notably, to their situation. When a gash is about to be made in the upper part of the neck, the head is thrown back, and the pharynx is brought well forward. The incision must be deep indeed to reach the carotids or jugulars. Again, when the incision is over the larynx, the cartilages oppose so much resistance that the power of the suicide is generally expended before the needful depth is attained. Lastly, when the incision is still lower, the sterno-mastoids contract spasmodically on the stimulus of the knife, and defend the deeper structures. It is probable also, as pointed out by Mr. Hilton in his Anatomical Lectures, that when the windpipe is opened below the glottis, air immediately escapes from the lungs; consequently, the chest-muscles which act upon the upper extremity lose to a certain extent their support, and the arm falls. Thus, the would-be suicide, if he have the desire, may be deprived of the ability to carry his attempt further.

2. Blood may be drawn, or may flow into the air-passages faster than the sufferer can expel it; and asphyxia may quickly result. Or a clot of blood may get into the larynx, and destroy life.[1]

3. Air may enter a wounded vein, and cause sudden death, or give rise to alarming symptoms, which may either subside, or ultimately lead to a fatal result. This accident is most likely to occur if one of the large veins at the root of the neck has been opened, but not cut through. It may happen, however, in wounds of the smaller veins, and even though the seat of injury be comparatively high in the neck.[2]

Le Gros Clark mentions a recent case in which the incision was above the hyoid bone. Death resulted in about twenty-four hours. Dyspnœa came on gradually, and increased until life was extinct. "At the autopsy, the blood in the heart was found churned up and frothy. . . . . Investigation at the seat of injury suggested that a half-divided vein, which had been ligatured only on its distal or bleeding side, had slowly absorbed air, the admixture of which with the blood had proved fatal."[3]

4. The divided structures may be so displaced as to impede or absolutely obstruct respiration. For example, if the incision is above the hyoid bone, the tongue may be cut through, and its posterior portion falling back, may occlude the larynx, and produce suffocation. Such a case has lately come under my observation in Guy's Hospital.

If the incision is between the hyoid bone and the thyroid cartilage, the epiglottis may be divided, or separated from its connections, and may give rise to alarming symptoms.

In a case of cut throat recorded by Mr. Houston,[4] the epiglottis, loosened from its upper and lateral attachments, was left hanging by its pedicle to the back of the pomum Adami, and having fallen over the rima glottidis, obstructed respiration so completely that, within a few minutes after the accident, symptoms of suffocation ensued. The epiglottis was raised, brought over the edge of the thyroid cartilage, and secured by a single stitch to its anterior surface. Respiration returned. The man in a short time sat up, and attempted to speak, but was unable to articulate.

If the laryngeal cartilages are cut through, a detached portion of one or other may get into the glottis.

A remarkable instance is mentioned by Sir

[1] See Hilton's Clinical Lectures, Guy's Hospital Reports, 3d Series, vol. xiii., p. 31.

[2] See p. 475 of this work, on "Entrance of Air into Veins."

[3] Lectures on the Principles of Surgical Diagnosis, delivered at the Royal Coll. of Surgeons, p. 225; also British Medical Journal, August 21, 1869.

[4] Dublin Hospital Reports, vol. v., p. 315, cited by Ryland.

C. Bell.[1] A man who had cut his throat suffered occasionally from great difficulty of breathing, accompanied by a flapping sound in the throat. After death it was found that one of the arytenoid cartilages had been divided and hung by a membrane. It vibrated in the chink of the glottis, "like a pea in a cat-call," during life; and finally acting as a foreign body it caused suffocation.

If the trachea is cut through, the divided portions are liable to become very widely separated, and the soft parts may intervene and prevent the free entrance of air.

Casper[2] relates an instance in which it appeared evident that death resulted from such cause. Richet[3] in 1854 communicated to the Société de Chirurgie a very interesting case in which the œsophagus projected forwards and became interposed between the cut ends of the divided trachea.

5. Emphysema may occur in any case in which an opening has been made into the air-passage below the glottis, and in which the expired air cannot find free exit. It may be especially looked for, if the wound through the integuments does not correspond in situation and proportionate extent with that made into the larynx or trachea. Such emphysema may spread rapidly through the subcutaneous areolar tissue of the head, neck, and thoracic parietes, and even as far as the scrotum;[4] or, taking the course of the trachea and œsophagus, it may reach the mediastina. Hilton states that emphysema about the phrenic nerves may so far interfere with their functional integrity as to lead to a fatal result. It is said that in wounds of the larynx, emphysema may extend through the submucous tissue, and, by constricting the glottis, rapidly produce suffocation. As a general rule, however, emphysema is not in itself a dangerous complication.

6. The voice may be modified, or entirely lost, either as an immediate and direct effect of the injury, or subsequently, in consequence of inflammatory changes. The manner in which the voice is affected, and the persistence of the affection, vary with the parts especially involved. If the windpipe is opened below the vocal cords, air may escape through the wound, and aphonia may result. In such cases, however, the voice may be temporarily restored by closing the wound, or by approximating the divided structures by a change of position.

7. Dysphagia, or even absolute inability to swallow, may immediately result, or may subsequently arise. Saliva, mucus, food, and drink, may escape through the wound; and much suffering may be occasioned. Such symptoms are most certain to occur if the food-passage has been extensively opened; but they may arise even though the incision has not penetrated beyond the air-passage. In consequence of inflammation, or of some nerve-lesion, it may happen that during deglutition the epiglottis does not become properly lowered; or the larynx is not carried far enough upwards and forwards. Consequently fluids, and even solids, may traverse the glottis, get into the trachea, and issue from the wound. Such an occurrence is by no means uncommon after tracheotomy, in cases of diphtheria.

8. Inflammation and œdema of the parts about the glottis may rapidly supervene, and endanger life.

9. Abscesses and purulent effusions, originating in the immediate neighborhood of the wound, may spread rapidly in various directions, through the loose laminated areolar tissue, and produce the gravest symptoms. Sometimes they run down to the root of the lung, or implicate the pleura, and fatal results ensue. Sometimes by pressure they impede respiration, or interfere with the venous circulation, and cause œdema.

10. Bronchitis and bronchopneumonia are common and often dangerous after-complications. They may be caused by extension of inflammation from the wound, by admission of unwarmed, unmoistened air into the lungs, or by irritation set up by the entrance of blood, pus, or foreign bodies, or portions of food, drink, etc., into the air-passages. In eight out of ten fatal cases of cut throat, recently treated in Guy's Hospital, in which the more immediate effects of the injury had been survived, death was due to these affections.

11. The natural passages may become constricted during cicatrization, or may be obstructed by the growth of exuberant granulations round the wound. Such complications require very careful management, for they are almost certain to increase in severity and importance with the lapse of time.

12. A fistula opening into the air-passage or the gullet may remain after the wound generally is healed. Such a complication is very rare, but numerous well-authenticated instances are on record.[1] It is most likely to occur in cases in which portions have been entirely cut away, or in which there has been very wide separation of parts, and healing has been very slow.

[1] Surgical Observations, vol. i., p. 44.

[2] Handbook of Forensic Medicine, New Sydenham Society's Translation, vol. ii., p. 18.

[3] Quoted in Nouveau Dictionnaire de Médecine et de Chirurgie, vol. ix., p. 640.

[4] See cases recorded in Plaies du Larynx, de la Trachée, etc., pp. 53, 71. Par le Dr. Horteloup. Paris, 1869.

[1] See Horteloup, op. cit., p. 77 and p. 117.

Dr. Gairdner[1] narrates the case of a man who cut his throat with a razor, dividing the larynx at the upper part of the cricoid cartilage, and the œsophagus also. The cut extremities receded from each other to the distance of at least three inches. Attempts were made to unite the divided larynx by means of sutures, and to pass a gum-elastic catheter from the nostril into the œsophagus, but without success. Ultimately the man recovered, with an aperture in the front of the neck, through which respiration was performed, and through which liquid nourishment was conveyed into the stomach by means of an elastic tube, introduced at each meal into the lower portion of the œsophagus. Two years after the infliction of the wound, this patient was strong and fat, and had all the appearance of a person enjoying excellent health.

Some of the more special effects and complications, which vary with the situation of the wound, may now be discussed.

a. Deep wounds between the lower jaw and the hyoid bone, besides dividing all the superficial structures, and the depressor muscles of the jaw, and elevators of the hyoid bone, may involve the lingual and facial bloodvessels, the hypoglossal nerves, and the submaxillary glands and ducts. They may penetrate the floor of the mouth to a greater or less extent, and partially or even completely sever the tongue. Such wounds are very dangerous. In nine out of eleven cases of which I have particulars, they proved fatal. They are usually attended by profuse hemorrhage. They gape widely when the head is thrown back. Saliva, mucous discharges, and alimentary materials, attempted to be swallowed, escape freely. Great dryness of the fauces and thirst are usually complained of. Articulation may be impaired, and vocalization enfeebled. Death may ensue from loss of blood, from obstruction of the larynx by blood coagulated in the back of the mouth or upper part of the pharynx, or, as in the case already referred to, and in others that might be quoted, the posterior portion of the divided tongue may fall backwards and produce suffocation.

b. Wounds through the thyro-hyoid membrane penetrate into the pharynx, and may partially or completely sever the epiglottis, the aryteno-epiglottidean folds of mucous membrane, and even the arytenoid cartilages or vocal cords. The superior thyroid vessels, and possibly the lingual, are liable to be involved, and the superior laryngeal nerves may be injured. These wounds are much more common than the preceding, and perhaps are somewhat less dangerous. They do not gape so widely, but permit the partial or entire escape of nutriment, etc. They are almost always attended by great difficulty in swallowing, on account of the convulsive cough produced by the irritation of the food in its passage over the imperfectly protected laryngeal orifice. They are liable to be very speedily followed by great difficulty in breathing, spasmodic fits of suffocative cough, complete loss of voice, and lividity of the face. Such symptoms indicate inflammation and œdema about the glottis and upper part of the larynx; and unless relief is afforded by appropriate treatment, death ensues. Sometimes a detached or partially detached portion of the epiglottis, or some other structure, gets into the glottis, and more or less seriously impedes respiration.

c. Wounds which penetrate the larynx are, as a rule, very dangerous; but more so perhaps on account of the after-complications to which they are especially liable than from their immediate effects. They are not usually attended by much hemorrhage. The important bloodvessels most likely to be involved are the superior thyroid. Deep gashes which happen to traverse either the crico-thryoid or the cricotracheal membrane, may reach the carotids and jugulars more easily than wounds made with equal force across other parts of the front of the neck. Breathing, swallowing, and vocalization are affected in a manner and to an extent varying with the precise seat of the injury and the structures involved. Sometimes the symptoms are apparently very anomalous. A wound through the upper part of the thyroid cartilage may involve the arytenoid cartilages; and separated portions of one or the other may occlude the glottis, or becoming necrosed may subsequently lead to serious, if not fatal, complications. Inflammation and œdema about the glottis are very liable to occur; and the inflammation may rapidly extend along the trachea and bronchi to the lungs. If the earlier dangers are escaped, others may arise at more remote periods, from exuberant growth of granulations, and thickening of the mucous membrane in the neighborhood of the wound, or still later, from contraction of the cicatrices.

A patient was recently under my care in Guy's Hospital, whose larynx had been wounded by a bayonet during the American War. The wound healed very slowly; but at last he thought himself well, although his voice was much impaired. After a time he began to suffer from difficulty of breathing, which gradually but certainly increased. When he came under my care, his voice was reduced to a whisper, and, as he said, it was "hard work to get a breath." Laryngoscopic examination showed great and irregular constriction of the upper part of the larynx. The vocal cords could not be seen. One night, suffocation impending, tracheotomy was performed. Great relief immediately followed, and under subsequent treatment he became

[1] Edin. Med. and Surg. Journal, vol. xvi., p. 353.

able to breathe to some degree through his larynx, and his voice was much improved.

Punctured wounds through the thyroid cartilage occasionally penetrate between the vocal cords, or injure one or both of them. In such cases œdema about the glottis almost invariably occurs, and produces death by suffocation.

Sir C. Bell[1] mentions an instance in which a young woman, who had inflicted a wound in this situation with a penknife, was suffocated some months afterwards by the exuberance of the granulations which arose from the edges of the wound, and filled up the aperture of the glottis.

When the cartilages of the larynx are divided entirely across (which, however, rarely happens), the upper portions are drawn upwards by the elevator muscles, and the lower portions downwards by the depressors. Thus a large gaping wound is produced, which is usually complicated with injury of the anterior wall of the pharynx.

Ordinarily, wounds of the larynx do not gape much; and the free escape of air, blood, mucus, and pus, may be hindered. In such cases the occurrence of emphysema, and the entrance of blood, etc., into the air-passages, are proportionately favored.

d. Wounds which divide the trachea are usually attended by considerable hemorrhage; and there is great danger of the entrance of blood. The superior and inferior thyroid arteries and the thyroidea ima, when present, as well as the thyroid veins and superficial jugulars, are liable to be involved. The thyroid body may be implicated, and if so, it bleeds freely. The recurrent laryngeal nerves are sometimes injured. If the trachea is only partially cut across, the edges of the wound separate only slightly from each other, and are easily kept in contact by bending the head and neck towards the chest. Sometimes, however, the trachea is completely divided. In such case the two ends separate very widely from each other, and the lower portion is drawn downwards at each inspiration towards the thorax, and more or less under cover of the neighboring parts. Thus respiration becomes seriously impeded.

Richet[2] records a remarkable instance in which the trachea was obliquely divided through four or five of its rings. The separation between the two portions measured more than two inches, and was increased by about another half an inch during inspiration. When left to itself the lower portion plunged down behind the sternum almost into the mediastinum; it could be seen to descend still lower at each inspiration, and to ascend again during expiration. All attempts to secure union failed. Suffocation impended when the wounded surfaces were brought together. The patient ultimately recovered, but an opening into the trachea remained.

When the trachea is completely divided transversely, the œsophagus rarely escapes. Sometimes it is wounded, occasionally entirely severed. Wounds of the œsophagus may be recognized by examination with the finger; their existence is indicated by the escape of materials swallowed through the wound. But, as already stated, such escape may sometimes take place although the gullet is uninjured.

In cases in which both the trachea and œsophagus are divided, the danger to life is necessarily very great. But even under such circumstances recovery may take place, as for example in the instance already quoted (p. 869).[1]

Treatment.—1. When called to attend a case of wound of the neck, the surgeon's first care must be to *arrest hemorrhage.*

Venous hemorrhage, as a rule, may be effectually stopped by pressure; but occasionally it may be necessary or desirable to apply one or more ligatures. If the external jugular or any other superficial vein is wounded, gentle but continued pressure with the finger, beneath which a small pad of lint has been placed, is generally all that is required, even though the bleeding has been considerable. If the internal jugular is wounded, the hemorrhage is profuse, and very rapidly proves fatal, unless prompt assistance is afforded.

Mr. Bryant[2] has recorded the case of a little girl, nine years of age, who stumbled whilst carrying a chamber utensil in her hand, and fell on the broken china. The right internal jugular vein was wounded, and such profuse hemorrhage followed, that she died five minutes after her admission into Guy's Hospital.

If it is evident that some large vein is injured, but the precise source of the bleeding cannot be at once made out, the wound should be immediately plugged with small pieces of sponge, and pressure with the finger applied as long as necessary. The pressure may be maintained by means of carefully adjusted strips of adhesive plaster. But this treatment is sometimes followed by serious results.

A man was admitted into St. George's Hospital July 14, 1847, who had cut his throat with a penknife. On the left side of the neck, a little below the cricoid cartilage, was a wound about an inch and a half in length, extending

[1] Op. cit., vol. i., p. 45.
[2] Gazette des Hôpitaux, 1855, p. 35.

[1] In Hennen's Military Surgery, 3d edit., 1829, p. 368, is a case communicated by Dr. James Johnson. A Malay cut his comrade's throat while asleep. The windpipe was divided, and also half the œsophagus. The sufferer was supported by enemata, and gradually recovered.
[2] Pathological Transactions, vol. viii., p. 101.

transversely across the space between the sterno-mastoid and trachea, partially dividing the muscles in this situation, and passing for some distance under the skin towards the clavicle. There had been profuse hemorrhage, and dark blood was still welling up. The wound was plugged with sponges, and pressure with the fingers applied. At 1 P.M. the wound was dilated upwards and downwards; no bleeding vessel was discovered, but it was evident that the bleeding proceeded from the lower end of the wound. About half a pint of blood was lost before the sponges were reapplied. The wound gradually suppurated. When the last sponge had been removed a deep granulating cavity was seen, with a slough in the direction of the sheath of the vessels. On July 22, at 5 P.M., hemorrhage suddenly recurred to an alarming extent, and the patient died in the evening. On inspection a slough was found completely destroying the front wall of the internal jugular vein for three inches of its extent. The posterior half only of the vessel remained. The sloughing extended upwards from about an inch above the junction of this vein with the subclavian. The anterior wall of the common carotid artery had also been wounded; the opening was small, and was blocked up by lymph and coagulum, which were intimately adherent to the edges of the wound.

If the hemorrhage is not speedily and satisfactorily stopped by pressure, and its precise source can be discovered, the safest plan is to ligature the vein above and below the wounded part.[1]

If one of the large veins, as the jugular or subclavian, should be slightly wounded on one side, according to Roser, it may be better to close the opening by means of a fine suture, rather than to ligature the whole vessel. Or a [pin or a] tenaculum may be passed through the edges of the opening, and a ligature applied. Cases in which this proceeding was adopted with success are referred to by Legouest.[2]

Arterial hemorrhage demands for its arrest the promptest measures. In wounds of the carotids or their principal branches, death commonly ensues before surgical aid can be obtained.

During the summer of 1859, one of the inmates of St. George's Hospital committed suicide by cutting her throat. She was almost immediately seen by the house surgeon, but had already ceased to breathe, and was quite pulseless. There was a deep gash in the throat, dividing the left common carotid artery and wounding both internal jugular veins.

But it must not be supposed that even severe wounds of the carotids are of necessity *immediately* and invariably fatal. Numerous cases to the contrary are on record.[1]

If in a case of wound of the neck, accompanied by free arterial bleeding, assistance should arrive before the patient is dead, pressure should be at once applied over the wound; or the finger should be thrust into the wound, and made to press in the direction from whence the bleeding comes; or the common carotid should be compressed against the transverse process of the fifth and sixth cervical vertebræ. The wound may then be enlarged, if needful, and the wounded vessel sought. If found, the vessel must be secured, both above and below the wound, by ligature or by torsion. The latter method may be less generally or less rapidly applicable, but it has the advantage of leaving no dangling threads which the determined suicide may tear out. If the wounded vessel cannot be found without prolonged and careful dissection, as sometimes happens, it is better to apply a ligature at once to the common carotid.[2] Before doing so, however, it should be ascertained that the bleeding is stopped by compressing this vessel. The results of ligature of the common carotid on account of hemorrhage from wounds cannot be considered as very unfavorable, if regard be paid to the extreme danger of the conditions under which the operation has been performed in such cases.

Dr. Pilz[3] in his analysis of 586 cases of ligature of the common carotid gives forty-four cases of punctured and incised wounds in which the operation was performed. In twenty cases recovery ensued; in twenty-four, death. Out of eighty-five cases of gunshot wounds and injuries by military arms, however, only thirty-one recovered.

Lacerated and punctured wounds involving the carotid arteries are less likely to prove immediately fatal than incised wounds. Ample time for the application of a ligature is sometimes afforded.

Abernethy has related a case in which the internal carotid, and all the branches in front of the external carotid, were wounded in a man who was gored in the neck by a cow.

[1] See Gross on "Wounds of the Internal Jugular Vein," Amer. Jour. Med. Sciences, Jan., 1867. In this elaborate article numerous cases are quoted. A case in which the internal jugular vein was partially divided with a razor, and the patient saved by securing it with a ligature, is given by Dr. Morgan of Geneva, Amer. Jour. Med. Sciences, vol. xviii., p. 330. He refers to two other successful cases of ligature of the vessel, by Dr. Stevens of New York, and Dr. Gibson of Philadelphia.

[2] Op. cit., p. 428.

[1] See Taylor's Medical Jurisprudence, 1865, p. 513. Larrey, Clinique Chir., t. ii., p. 128.

[2] Le Gros Clark refers to two such cases under his care, in each of which a good result was obtained. Op. cit., p. 222; see British Medical Journal, Aug. 21, 1869. Also Med.-Chir. Trans., vol. xxx., p. 15.

[3] Dr. Pilz, Archiv. f. Klinische Chirurgie, ix., 1868. Schmidt's Jahrbücher, No. 7, 1868. Quoted in Half-Yearly Abstract, 1868.

Death did not diretly follow, and there was time to have recourse to the ligature.[1]

A remarkable case of punctured wound of the carotid came under my observation two years ago. A little girl seven years of age was playing in the room where her father was preparing hydrogen gas. An explosion took place, and a triangular portion of one of the glass bottles was driven into her neck. Profuse hemorrhage immediately occurred, but whether venous or arterial could not be made out from the description given. A piece of lint was applied, and she was brought up from Greenwich to Guy's Hospital, and admitted under the care of Mr. Hilton. On admission the child was cold and blanched, with feeble pulse; but bleeding had entirely ceased. There was a wound about an inch in length in the left carotid region. On the eighth day after the accident, hemorrhage recurred, and the common carotid was tied. Nine days later bleeding to a slight extent took place, but was arrested by plugging the wound with sponge. Repeated epistaxis occurred during the following days, and weakened the child perceptibly. The sponges became very offensive; but there was no further bleeding from the wound for eighteen days. Then a considerable quantity of blood was lost. The child gradually sank and died ten days later, or rather more than six weeks after the accident. On dissection, the common carotid was found to have been punctured in front and behind. The sharp point of the fragment of glass must have traversed the interior of the artery. Behind the wounded vessel was an abscess implicating the sympathetic nerve.[2]

2. In wounds of the neck which involve the air-passages, death is almost as likely to result from suffocation as from loss of blood. To remove, therefore, or obviate as far as possible any impediment to free respiration, may require as much promptitude and skill on the part of the surgeon as the arrest of hemorrhage. It may be necessary, without a moment's delay, to clear clots of blood from the back of the mouth or pharynx, or to resort to artificial respiration to aid the expulsion of blood, or even to suck it from the trachea. It is very rarely, however, that any such measures can be carried out in time to be of avail: unless indeed, as sometimes happens, the occasion should arise during the performance of a surgical operation.

If a portion of the divided tongue should impede respiration, it must be at once drawn forwards, and prevented from again being retracted or falling back, by means of ligatures passed through it. This was successfully accomplished in a case of cut throat, recently under the care of Mr. Cock, in Guy's Hospital.

If a severed portion of the epiglottis should hang loose, it may be removed; or an attempt may be made to secure it in position by fine sutures. The former is probably the safer plan, being less likely to be followed by dangerous inflammation and œdema about the entrance to the larynx. Numerous instances show that the loss of a portion of the epiglottis, whether by injury or disease, does not necessarily entail any serious consequences.[1]

3. When all bleeding has ceased, and no immediate hindrance to respiration exists, the cut surfaces of the wound should be brought together. This may generally be accomplished effectively, and with the greatest safety, by putting the head and neck into proper position. The patient being in bed, the shoulders should be well raised by pillows, and the head and neck bent forwards so far as may be necessary to keep the surfaces of the wound in good apposition, without impeding respiration. But in some cases the patient is absolutely unable to breathe except through the wound; and any attempt to bring the parts closely together involves the risk of suffocation. To maintain the head in position, bandages may be passed from each side of a firm nightcap to a roller applied round the chest; or sand-bags may be arranged on each side of the head and neck. As a general rule, neither sutures or adhesive plasters should be used. They are at best needless in most cases, for primary union can scarcely be expected; and, indirectly, they may in various ways prove sources of danger. For example, if the edges of the wound are closely united, and bleeding should recur, the blood, instead of escaping externally, may trickle into the air-passage, and accumulating there may cause suffocation. This is especially liable to occur while the patient is insensible, or faint from loss of blood, and unable to make the necessary effort to expectorate. At a later period purulent discharges, if they cannot find free exit externally, may pass into the air-passage, or otherwise give rise to serious trouble. Again, inflammation and œdema of the neighboring parts and of the mucous membrane of the larynx may ensue. Under such circumstances viscid mucus collects, and, if it cannot be expelled through the wound, obstructs the air-passages, and increases the existing difficulty of breathing. Lastly, closure of the wound by sutures is likely to be followed by emphysema. In some cases, however, both plasters and sutures may be employed with safety

[1] Surgical Works, vol. ii.

[2] Instances of wounds of the carotid not proving fatal are recorded by Larrey and other surgeons. See London Medical Gazette, vol. iii., p. 250. Nouveau Dict. de Méd. et de Chir., art. Carotide. In his Clinique chirurg., t. ii., p. 128, Larrey records the case of Arrighi, afterwards Duke of Padua, whose carotid was torn by a bullet. A soldier near put his finger into the wound, and stayed the bleeding until Larrey's aid was obtained. [See also Am. Journ. of Med. Sc., Jan., 1879, p. 281.]

[1] See cases quoted by Horteloup, op. cit., p. 58.

and advantage, at a period when the surfaces are healthily granulating. Indeed, Nélaton[1] recommends, under such circumstances, the insertion of several sutures in all cases, in order to prevent the turning in of the edges, and to avoid the risk of a permanent fistula. But it sometimes happens that the discharges become confined, or great pain is occasioned, and the sutures have to be removed; or they may be torn out during the violent coughing which so commonly occurs.

In certain exceptional cases sutures may be necessary from the first. Thus, if the cartilages of the larynx are cut in several places, and the different pieces are much separated from each other, they may be joined by one or more sutures passed through the cellular tissue surrounding them. If complete division has been effected between the thyroid and cricoid cartilages, and these parts are separated from each other, one or two sutures may be used to approximate them. And if the trachea is completely divided across, it may be necessary to have recourse to one or more sutures. In every case, however, it is better to try the effect of position first; because, if the divided parts have not separated to any great extent, sufficient approximation may be thus accomplished. If sutures are used, and respiration should become obstructed, or if the cellular tissue around the wound becomes emphysematous, they must be instantly removed.

The patient should be surrounded by a moderately warm and moist atmosphere, and the wound lightly covered by a strip of wet lint or linen. A skilful nurse should be in constant attendance to prevent any fresh suicidal attempt, and to clear away the blood and mucus that may from time to time collect in the wound. Expectoration, if very difficult, may be rendered easier by closing the wound with the fingers at the moment the effort is made.

Every means should be adopted to favor granulation and cicatrization of the wound.

The respiration should be carefully watched. Difficulty of breathing may arise at any period from one or other of the various causes already specified, and require immediate relief. Care should especially be taken to allay as far as possible all symptoms indicating incipient inflammation of the larynx or trachea. Such symptoms may arise very soon after the infliction of the injury. If suffocation impends, and is not at once relieved by clearing out or enlarging the wound, or by introducing a tracheotomy canula through it, a fresh opening into the air-passage must be made below the wound, and a canula inserted. Some surgeons consider that tracheotomy may be advantageously performed in any case of extensive transverse wound involving the air-passage, as soon as all hemorrhage has ceased, and the shock of the injury has been recovered from. When this has been done, the edges of the wound may be united without risk of suffocation; and after the wound is healed, the canula may be withdrawn, and the opening in the trachea closed.

Bronchitis, as already stated, very often occurs, and if unchecked, is soon followed by pneumonia or pleurisy. Every care must be taken to obviate this source of danger by regulating the temperature and moisture of the atmosphere about the patient, and by preventing the ingress of irritating discharges, and favoring their expectoration.

When the pharynx or œsophagus is laid open, and especially when the latter tube is completely divided, great separation of the edges of the wound takes place during swallowing, and the ingesta partially or entirely escape through the wound. In such case, the elastic tube of a stomach-pump, or a common elastic catheter of large size, should be used to convey nourishment to the stomach. The tube should be introduced through the mouth,—not through the nose, as some surgeons have recommended,—and passed into the œsophagus a short distance beyond the wound. It may be used two or three times daily. The tube should on no account be passed through the wound; for, if this be done, union is very seriously interfered with. Before any fluid nourishment is poured through it, care should be taken to ascertain that the tube has not been passed into the trachea. This may be ascertained by placing a lighted taper at the end of the tube, and observing if the flame is affected. It sometimes happens that the introduction of the tube is very distressing to the patient, and produces much irritation about the wound: under these circumstances, nutrient enemata must be administered. When swallowing is again attempted, the patient should be directed to lean somewhat backwards, and to swallow small portions very slowly.

The general condition of the patient is often such as to require the most careful management, and to occasion the gravest anxiety. In some cases there is low muttering, in others furious delirium, consequent upon habits of intemperance. Sometimes periods of intense excitement are followed by corresponding periods of exhaustion. Sometimes unvaried depression and despondency prevail. Such symptoms may prove more difficult to combat than most of those more directly associated with the effects of the wound; and, when they occur, speedy death too often results, even in

[1] Éléments de Pathologie chirurgicale, t. iii., p. 340.

cases in which the injury inflicted has been comparatively trifling.

As a general rule, the patient should not be kept low. Plenty of nutritious food, and wine or spirits must be given, according to the circumstances of the case, due care being taken not to over-stimulate. The danger of exciting inflammation by food and stimulants is less than the risk that the patient may sink exhausted from want of sufficient nutriment.

Exuberant granulations obstructing the air-passages have already been referred to as occasionally becoming developed around the wound. Such granulations are sometimes met with in cases of tracheotomy.[1] They are best treated by the repeated application of solid nitrate of silver. In some instances it may be necessary, if possible, to open the trachea lower down.

Constrictions of the larynx or trachea occurring during cicatrization, or from subsequent contraction, may render necessary the immediate performance of tracheotomy. After this has been done, the constrictions, in some cases, may be dilated by the passage of bougies. In other cases, the use of the knife is also required. Several remarkable instances have been published, in which more or less successful results have been obtained.[2]

Laryngeal and tracheal fistulæ.—Fistulous openings occasionally, though very rarely, remain after general healing has taken place. They are most likely to result in cases in which considerable portions of the air-tube have been destroyed, or in which constrictions have occurred higher up. If no constriction exist, or after any previously existing constriction has been satisfactorily dilated, the fistula may generally be closed by paring the edges and bringing them together. Sometimes it may be necessary to detach the skin from the deeper structures to some slight extent round the opening, or to make lateral incisions to facilitate the drawing together of the margins. The sutures should be pretty close, and should include so much tissue as to render the occurrence of emphysema improbable. After the operation, gentle pressure should be applied, especially during coughing. In the case of a very large opening, skin may be taken from the most convenient neighboring part, and adapted as may be requisite. No operation of this kind should ever be attempted until it has been absolutely ascertained that respiration will not be impeded by closure of the fistula.[3]

[1] See paper by T. Smith, Medico-Chirurg. Trans., vol. xlviii., p. 227.

[2] Liston, Edin. Med. and Surg. Journ., No. xciv., p. 118, and Elements of Surgery, 2d ed., p. 435. Horteloup, op. cit., p. 123.

[3] See an excellent case by M. Le Fort, full details of which are given by Horteloup, op. cit., p. 127 *et seq.*

Other Injuries of the Pharynx and Œsophagus.

The pharynx and œsophagus may be wounded from within by sharp-pointed instruments, or other foreign substances thrust through the mouth.

If in an injury of this kind the side of the pharynx is penetrated, dangerous or even fatal consequences may arise from implication of one of the larger vessels.

The following case illustrates this form of injury, and the treatment it may be necessary to adopt. A boy, aged seven, was admitted into St. George's Hospital, May 12th, 1850. A week previously, he fell while holding the sharp end of a parasol in his mouth. The point was forcibly thrust to the back of the fauces, and very nearly made its reappearance through the skin at the side of the neck. Considerable hemorrhage took place at once, and recurred at night. About the seventh or eighth day a slough came from the interior of the mouth; and arterial hemorrhage to the extent of about five ounces occurred. The bleeding was stopped by pressure applied externally; and the boy was soon afterwards brought to the hospital. On examination, a swelling about as large as half a hen's egg was found below and a little behind the left ear, and the skin for some distance around was discolored, as from extravasation of blood. Fluctuation was detected on the summit of the swelling. This being opened, pus with much blood-clot escaped, but no hemorrhage ensued. Two days afterwards a gush of arterial blood followed a fit of coughing. Mr. H. C. Johnson cut down upon and tied the common carotid artery. No unfavorable consequences ensued. Nine days afterwards the ligature was found loose; it soon came away. The wound healed; and on June 12th, twenty-seven days after the operation, the child was discharged in a very favorable state.

In some cases portions of food or other contents of the pharynx may pass through the wound and set up inflammation, followed by abscess.[1] In other cases fragments of the foreign substance which has produced the wound may be broken off, and remain impacted, and give rise to similar results.[2]

Slight wounds of the œsophagus, such as may be produced during the passage of hard, sharp substances towards the stomach, usually heal without serious symptoms. Dangerous consequences, however, may ensue if a wound of this portion of the gullet is accompanied by severe injury of neighboring parts, as is shown by the following case, related by Dr. Parkes.[3]

[1] See C. H. Moore, Lancet, 1864, vol. ii., p. 287.

[2] See Vincent, Med.-Chir. Trans., vol. xxix., p. 38. Larrey, Clinique chirurgicale, t. ii., p. 134.

[3] Path. Trans., London, 1848–9, p. 40.

A young, healthy, athletic juggler, on the evening of January 24, was exhibiting the trick of swallowing a sword, made of iron, about two feet long, three-quarters of an inch broad, and round and blunt at the end. When he had passed the sword nearly to the root of the neck, he felt it strike against some obstacle, past which he violently pushed it. He immediately withdrew the sword, gave a sudden leap in the air, then fell and fainted. When he recovered, he vomited violently. The vomited matters consisted of the contents of the stomach, without the slightest tinge of blood. Intense pericarditis, marked by characteristic symptoms, came on forty minutes after the accident, and he died in the evening of the second day. The sword had penetrated the anterior wall of the œsophagus five and a half inches below the pharynx, and passed into the pericardium. Lymph was effused over the whole parietal and visceral pericardium. The important bloodvessels and other organs in the neighborhood were uninjured.

In some instances the walls of the œsophagus have been perforated by the surgeon, while attempting to pass a bougie or tube, in certain diseased conditions of the parts. In some such cases the instrument has passed into the mediastinum; in others, even into the pleural cavity.

In all cases, in which there is reason to suspect the existence of any serious internal wound of the gullet, solid food should be interdicted, and only the blandest fluids swallowed. Indeed, it may be better that no attempt to swallow should be made until time has been allowed for healing to take place to a certain extent.[1]

Rare instances are on record in which the œsophagus has been ruptured during violent vomiting.

Boerhaave[2] relates the case of the Baron Vassenaer, who habitually made himself vomit after excess at table. At last, while vomiting very violently, he was seized with sudden pain, and died in eighteen hours. Transverse rupture of the œsophagus (which was otherwise healthy) was found three fingers' breadth above the diaphragm. A recent case is narrated by Dr. Griffin[3] of Banbury, in which the œsophagus of a healthy man was ruptured during violent vomiting.

Other Injuries of the Air-Passages by Mechanical Violence.

The following injuries, singly or complicated one with another, may be caused by manual compression, blows, kicks, falls upon projecting corners or edges, or by hanging, or other modes of strangulation.

1. *Contusions.*—A blow upon the larynx may prove suddenly fatal by shock, or by arrest of respiration from spasm of the glottis. If life is not altogether extinct, laryngotomy should be at once performed, a tube introduced, and artificial respiration kept up as long as needful, or while hope remains.[1] Short of an immediately fatal result, insensibility of longer or shorter duration is a common effect of a blow or other sudden pressure upon the air-passage. The victims of the street-garotter are thus rendered unconscious before they are robbed, and often remain so for some time afterwards. Sometimes the symptoms which follow a blow upon the larynx are less severe, and may be subdued without having recourse to any operative measures.

The symptoms which commonly attend contusions of the larynx are great pain and tenderness about the seat of the injury, more or less swelling in the neighborhood, enfeeblement or total loss of voice, with little or no difficulty of breathing. Rest of the parts, and the application of leeches and warm anodyne fomentations, constitute the treatment generally required. Antimonials and mercurials may be useful in some instances.

2. *Fracture of the hyoid bone.*—Fracture of the hyoid bone is a rare but well-recognized accident. It is usually caused by direct violence, but in some instances has been attributed to muscular action.[2] It is occasionally found to have occurred during execution by hanging, but not so frequently as some have supposed.[3] The parts usually injured are the cornua, at or near their junction with the body. One or both may be broken. Much displacement of the fragments generally occurs. The symptoms are pain in the neck, inability to turn the head, dysphagia, or even total inability to swallow. The voice is hoarse, the patient having great difficulty and pain in speaking. Symptoms of suffocation occasionally occur, or may be produced by simple protrusion of the tongue. On examining the throat externally, crepitus, or some irregularity may be detected; and on looking into the mouth, not unfrequently ecchymosis and swelling of the mucous membrane may be found. The fragments occasionally perforate the mucous membrane, and more or less bleeding may occur.

In an interesting monograph on "Diseases and Injuries of the Hyoid Bone,"[4] Gibb has

[1] See a remarkable instance of a partially cicatrized wound of the œsophagus burst open by solid food which escaped into the thoracic cavity. Larrey, Clinique chir., t. ii., p. 161.

[2] Boerhaave. Quoted by Horteloup, op. cit., p. 23.

[3] Lancet, Sept. 4, 1869, p. 337.

[1] See a case by Liston in the Edin. Med. and Surg. Journal, vol. xix., p. 570.

[2] British and Foreign Medico-Chirurgical Review, vol. viii., p. 549.

[3] Casper, op. cit., vol. ii., p. 174. Taylor, Medical Jurisprudence.

[4] On Diseases and Injuries of the Hyoid or Tongue Bone, by G. D. Gibb, M.D., Churchill, London, 1862.

brought together more or less complete details of thirteen cases of fracture. In four of these the right cornu was broken, in five the left; and in one (that of a child) the middle of the body of the bone was broken. In two the precise seat of the injury is not stated. Two of the cases terminated fatally.

Treatment.—The displaced fragments must be restored to their proper position. This may be effected by passing the finger of one hand into the throat, and by the other hand manipulating the bone externally. The patient should be kept quiet, every attempt at speech avoided, and antiphlogistic regimen adopted. Inflammation may be relieved by the application of leeches. If great difficulty of breathing should supervene, laryngotomy must be performed. If the patient cannot swallow, or finds great difficulty and pain in doing so, the use of the œsophageal tube is requisite. If the passage of this tube produces much pain or inconvenience, nutrient enemata must be administered.

The following case described by Lalesque[1] affords a good example of fracture of the hyoid bone. A marine, aged sixty-seven, had his throat violently clenched by the hand of a powerful adversary. At the moment there was very acute pain, and the sensation of a solid body breaking. The pain was aggravated by every effort to speak, to swallow, or to move the tongue; deglutition was impossible, articulation indistinct, and he was unable to open his mouth without a great deal of pain. The left horn was broken near the body of the bone, and had pierced the mucous membrane, and given rise to considerable hemorrhage. He was fed by an œsophagus-tube for twenty-five days, and ultimately recovered.

Cases have occurred, in which detection of the fracture has been less easy than might have been expected.

The following is an illustration: A laborer, aged sixty-three, fell from a wagon on his face. Much blood issued from his mouth. He complained of severe pain in the neck, and was unable to turn his head. His voice was hoarse and difficult; he could not swallow; on attempting to drink, violent coughing was excited, and the fluid was rejected. The tongue was freely movable, and there was no pain on depressing it. The epiglottis did not appear to cover the larynx completely, nor to be in its exact position. Neither crepitus nor unusual mobility could be perceived about the hyoid bone, which seemed to preserve its continuity. The case was supposed to be one of injury of the laryngeal nerves and muscles and of the pneumogastric nerve. Medicine and food were administered by an elastic tube. The pain in the neck subsided, and its motions were restored. A hectic cough from which he had long suffered remained. The cough increased, the voice became scarcely audible, and the patient died exhausted, eleven days after the occurrence of the accident. On dissection, fracture of the hyoid bone was found. "One of the large cornua was broken and had become firmly imbedded between the epiglottis and rima glottidis, inducing the raised position of the epiglottis, loss of voice, and difficulty in swallowing."[1]

3. *Dislocation of the hyoid bone.*—Gibb has recorded[2] in the following words a case of dislocation of the hyoid bone in a patient under his care.

The patient, a man aged forty-five, "would feel a sudden click in the *left* side of his neck, which produced a sensation as if something was sticking in his throat. On examination, this appeared to me to depend upon a displacement of the left horn of the hyoid bone, and was generally reduced by throwing the head backwards, towards the *right* side, so as to stretch the muscles of the neck, and then suddenly depressing the lower jaw, and so putting the depressors of the hyoid bone into operation. He died some years after of pulmonary consumption. On examining his throat after death, I found a sort of pouch, which answered the purpose of a synovial capsule, embracing the horns of the left thyro-hyoid articulation. [?] It was filled with a clear fluid, had a comparatively large rhomboid sesamoid bone developed in its outer wall, and permitted an extraordinary amount of motion." This was the fourth case of the kind which had come under the notice of Gibb. All the patients were males. He subsequently met with a fifth case in which the patient was a female.

Reference is made in the work quoted to a paper, read in 1848 before the Parisian Medical Society, by Dr. Ripley of South Carolina, on "Dislocations of the Os Hyoides, especially illustrated in his own person, and the manner of reducing them." The latter process consisted "in throwing the head backwards as far as possible, so as to place the muscles of the neck on the stretch, then relaxing the lower jaw, at the same time gently pressing or rubbing over the displaced part, when the displacement becomes reduced after a few attempts with a click."

Two cases of dysphagia described by Abercrombie[3] are considered by Gibb to have been "examples of double displacement of the thyro-hyoid articulation."

4. *Fractures of the cartilages of the larynx.*—The cartilages of the larynx may be broken by a fall against some projection, or by a blow, or by forcible compression by the hand of an adversary, or by some other of the various modes of strangulation. This

[1] Journal univ. et hebdom., mars, 1833. Also American Journal Medical Sciences, vol. xiii., 1833, p. 250.

[1] Brit. and Foreign Med.-Chir. Review, 1851, vol. viii., p. 549. Schmidt's Jahrbücher, vol. lxviii., p. 215.

[2] Op. cit., p. 20, and Trans. of the Path. Soc. London, vol. x., p. 66.

[3] Diseases of the Stomach, 2d edit., 1830, p. 102.

lesion is most likely to occur after ossification has taken place, but it may be met with during childhood.[1] The fragments may be so displaced as to encroach upon the cavity of the larynx or pharynx; and occasionally the mucous membrane is perforated. Injuries of this kind are of extreme danger to life, on account of the various obstructions to respiration to which they may give rise. Such obstructions may be caused either immediately, by displacement of the fractured portions, by spasm of the glottis, or by entrance of blood into the air-passages; or subsequently, by inflammation and œdema of the lining membrane of the larynx, or by local or general emphysema.

In an excellent article recently published, M. Hénoque[2] analyzes fifty-two cases collected from various sources. To these I am able to add ten, two of which have been under my own care. It is worthy of special note, that every case in which the cricoid was fractured proved fatal.

The following is a summary of the sixty-two cases.

Cartilages fractured.	No. of cases.	Deaths.	Recoveries.
Thyroid only	24	18	6
Cricoid only	11	11	
Thyroid and os hyoides	4	2	2
Thyroid and cricoid	9	9	
Thyroid, cricoid, and os hyoides	2	2	
Thyroid, cricoid, and trachea	2	2	
Cricoid and trachea	2	2	
Cricoid, trachea, and os hyoides	1	1	
"Fractures of larynx"	7	3	4
	62	50	12

Fractures of the laryngeal cartilages are accompanied more or less constantly by the following signs and symptoms. The general contour of the neck is altered: there is usually flattening; but, in cases in which lateral compression has caused the injury, there may be undue prominence of the pomum Adami. Ecchymosis, and swelling of the neck due to extravasation of blood, or at a later period to inflammatory exudation, are commonly observed. The cartilages, or portions of them, are abnormally movable. Sometimes crepitation may be detected; but this must be carefully distinguished from the false crepitation produced by pressing the cornua of the thyroid cartilage against the spinal column. Emphysema may occur if the mucous membrane is lacerated.

The patient complains of great pain, either constant, or produced or aggravated by pressure or attempts at swallowing or speaking. There is almost always more or less difficulty of breathing, accompanied by lividity of face, coldness of skin, and smallness of pulse. The dyspnœa may be caused by displacement of the cartilages, or abnormal mobility of the points of attachment of the vocal cords; or by submucous effusion of blood; or by extravasation of blood external to the larynx. In a case recorded by Mr. Stokes,[1] blood was effused in the neighboring parts to such an extent as to push the larynx over to one side. Sometimes difficulty of breathing comes on quite suddenly, and very severely, several days after the injury. In such case it may be due to accidental displacement of some fragment, or to the supervention of acute œdema.

Convulsive cough and expectoration of frothy blood may immediately follow the injury. At a later period there may be copious expectoration of very offensive pus; and occasionally, even necrosed portions of the fractured cartilages may be coughed up. The voice may be affected to a variable extent. Sometimes it is hoarse; sometimes enfeebled; sometimes altogether lost.

Fracture of the laryngeal cartilages, however, may occur without giving rise to any marked symptoms, and without being attended by displacement or deformity. A case of this kind is recorded by Gibb.

Treatment. — In simple fractures with little or no displacement, and in which the breathing is easy, the parts may be steadied and supported by small pads of lint and strips of adhesive plaster. The act of swallowing should be carefully watched, and interdicted for a time if it should occasion manifest displacement of the fractured parts. Local antiphlogistics or leeches may be applied. If there is great and continued dyspnœa from the first, and especially if there is much deformity of the larynx, tracheotomy should be performed at once. If the first difficulty of breathing should have subsided, the propriety of op-

[1] Out of twenty-seven recorded cases analyzed by Hunt, five were in children. American Journal of the Medical Sciences, April, 1866, p. 378.

[2] Gazette hebdomadaire, September 25 and October 2, 1868. The following contributions are reviewed Gurlt, Handbuch der Knochenbrüche, vol. ii., p. 316. W. Hunt, Amer. Journ. of Med. Sci., April, 1866. Wales, Amer. Journ., January, 1867. Hamilton, Amer. Journ., April, 1867. Soc. Anat., December, 1866, p. 393, 518. Fredet, Considérations sur les Fractures traumatiques du Larynx (Paris, Delahaye, 1868). Keiller, Edin. Med. Journ., 1856, p. 527, 824. Helwig, in Casper's Vierteljahrschrift, 1861, p. 342.

For other cases see Dublin Quart. Journ., May, 1869; Lancet, 1869, p. 707; Gazette des Hôpitaux, 1868, Nos. 90 and 91.

[1] Dublin Quarterly Journal of Med. Science, May, 1869.

erating may be doubtful; but experience shows that delay in such cases may be emphatically dangerous.[1] The dyspnœa may recur suddenly at any moment, and almost without warning; and death may ensue. Tracheotomy must be insisted on whenever suffocation becomes imminent, at whatever period it may be. The operation insures at any rate temporary safety; and it may afford opportunity for the restoration of the displaced parts to proper position. Such restoration may be attempted by external manipulation, aided by a finger introduced through the mouth, or by a probe passed through the opening made in the trachea.

In eight out of the twelve cases above summarized, in which recovery took place, life was manifestly saved by the timely performance of tracheotomy, or laryngotomy. And in another of the cases (under my care in Guy's Hospital in January, 1862), the patient had apparently made his last gasp, but after tracheotomy had been performed, was brought back, as it were, to life, by long-continued artificial respiration. He lived for fourteen days, and then died of bronchopneumonia. Comminuted fractures of the cricoid and thyroid cartilages were found, with laceration of the mucous membrane.

5. *Rupture of the trachea.*—Partial or complete rupture of the trachea without corresponding laceration of the soft parts is occasionally, but very rarely, caused by external violence. Such an injury is generally fatal from obstruction to respiration.

Dr. Berger[2] relates the case of a man who was kicked by a horse, just below the lower jaw. There was hardly any wound, but the neck became much swollen. The breathing was greatly embarrassed, and general emphysema came on. The patient died in an hour and a half. The trachea was found almost completely separated from the larynx; about a third of the connection only remained. Several rings of the trachea were torn through. The larynx itself was uninjured. The lungs were much loaded with blood, and the trachea was full of coagula.

In the following case, which occurred in the neighborhood of Glasgow, the trachea was totally divided. A boy, driving the gin of a coal-pit, placed himself on the end of the lever. On stretching out his head to look at something, his throat came in contact with a post. Such was the force with which he was going round, that the trachea was ruptured across. He survived for several days, but in great agony.[3]

Mr. Long,[4] of the Liverpool Infirmary, has put on record a good instance of recovery after rupture of the trachea. This case also serves to show the treatment that may be employed under similar circumstances.

A railway laborer, aged twenty, while connecting two railway carriages, was caught round the neck by the coupling irons. When brought to the Infirmary, there was some abrasion of the skin of the neck, a little swelling, and slight emphysema. The voice was subdued. In the evening there was some difficulty of breathing, and considerable distension and pain in the neck. Similar symptoms came on at intervals during the five days following the accident, and became at last so urgent that an incision was made in the median line of the neck. The finger was introduced into a mass of clotted blood, but the trachea could not be found. On subsequently turning out the blood, a bubble or two of air escaped from the lower part of the incision just above the sternum. On further examination, it was found that the trachea had been completely divided, and that the lower portion, from which the bubbles of air came, had been pushed on one side. There was an interval of an inch or more between the separated portions of the air-tube. A long canula was introduced by Dr. Halford (then house-surgeon), and the blood which clogged the trachea was repeatedly sucked out. The patient became more and more relieved. The head was bent forwards so as to diminish the extent of the gap. Nine days after the accident the tracheal tube was removed, and a double piece of gauze placed over the opening. The wound entirely closed in about a month. When Mr. Long examined the patient about six months after the accident he observed a depression to exist "in the throat, just above the sternum, capable of holding a walnut;" this was increased doubly in depth and width during each inspiration. A fragment of trachea could be detected attached to the lower part of the larynx; below this nothing was felt like tracheal rings, but merely a fibrous tissue; his voice was hoarse, like that of a person suffering from the commencement of a cold; and when he breathed quickly and deeply, the sound produced was that of air passing a narrow tube. "I presume, therefore," says Mr. Long, "that a fibrous tube has been developed in the space existing between the upper and lower ends of the divided trachea."

Injury of the Larynx from the Inhalation of Flame.

Mr. Ryland appears to have been the first to direct attention to the effects produced on the larynx by the inhalation of flame, or of intensely heated air. In his "Treatise on the Diseases and Injuries of the Larynx and Trachea," he describes the post-mortem appearances observed in four cases; and remarks "that the symptoms during life were those of severe bronchitis, without any of that peculiar dyspnœa that results from an obstructed condition of the laryngeal aperture." Injuries of this kind are probably more frequent than is commonly supposed. It is easy to understand how they may occur. When the clothes are blazing round, or when the sufferer is in the midst of a burning house, any in-

[1] See cases recorded by Fredet, Gazette des Hôpitaux, 1868, Nos. 90 and 91. Also Fredet, op. cit.

[2] Med. Times and Gazette, 1856, p. 650; from the Berlin Medizin. Zeitung, No. 33.

[3] Beck's Med. Jurisprudence, 7th ed., p. 718.

[4] Med. Times and Gazette, July 26, 1856, and Oct. 15, 1859.

spiratory effort may draw some portion of flame or hot air at any rate as far as the glottis. The intense inflammation of the respiratory tract, which sometimes immediately follows an extensive burn, may be thus explained. Such inflammation must, however, be distinguished from the low form which so frequently supervenes at a later period.[1]

Out of twelve cases of inflammation of the larynx from inhalation of flame, under observation at St. George's Hospital, in nine the neck and face were severely burnt; in three the superficial burn was confined to the lower limbs and lower part of the trunk. In a few of these cases there was difficulty of respiration almost from the time of the injury; in others, symptoms of dyspnœa came on a few hours afterwards, or on the first or second day following the injury. Death occurred in the majority of cases on the first or second day, but in two cases as late as the eighth or ninth day. In those cases in which the burn had extensively injured the face and neck, symptoms of dyspnœa were noted very early. In the two cases in which death did not take place until a much later period, the burn affected only the lower limbs and lower part of the trunk; and difficulty of breathing did not come on until the second day after the injury, and at first was only slight. In both of these cases the affected parts were extensively and deeply injured; but it is proper to add that the patients were at a period of life when the constitutional powers are most capable of supporting the shock of such an injury. The patients in the other cases were children or aged persons.

The post-mortem appearances are as follows: The mucous membrane of the mouth is of a dark livid color, or inflamed and œdematous. The tongue is occasionally much injected. The mucous lining of the fauces, and sometimes that of the pharynx, is of a bright scarlet hue. The vascularity ceases, as a rule, at the junction of the pharynx and œsophagus. In one case, however, the redness was found to extend about an inch along the œsophagus; and in another, the whole length of the tube was of a dark livid color. The mucous membrane of the epiglottis, and of the aryteno-epiglottidean folds, is of a bright scarlet hue, and the submucous cellular tissue œdematous. The mucous lining of the larynx and trachea is inflamed, and shreds of lymph are occasionally seen on its surface. The lining membrane of the bronchi is often inflamed, and the tubes are loaded with thick yellow mucus. The pleuræ are rarely affected. The lungs, in most cases, are either congested or sprinkled with patches of a vivid red color, or in more advanced stages of inflammation.

[1] Treatise on the Diseases and Injuries of the Larynx and Trachea, by Frederick Ryland, 1837, p. 274.

In very extensive burns respiration is commonly much accelerated; and consequently, the early detection of laryngeal inflammation may sometimes be difficult.

The treatment should be antiphlogistic. Calomel and antimony may be administered with advantage, in small but frequently repeated doses, as soon as croupy breathing indicates the existence of inflammation of the larynx. It must be borne in mind, however, that in the low forms of pulmonary inflammation, which so frequently follow severe burns, the very opposite treatment is required.

Scald of the Larynx.

Dr. Marshall Hall[1] appears to have been the first to publish a full account of this form of injury.

The accident happens usually to young children, and generally occurs during attempts to drink, by mistake, boiling water from the spout of a teakettle or other culinary vessel. The effects of such attempts, except in a few rare instances, are not, as might be supposed, to cause injury and inflammation of the œsophagus and stomach. Fluid of boiling temperature taken into the mouth is rarely, if ever, swallowed. It is arrested in its onward course by spasmodic action of the muscles of the pharynx, and efforts to expel it are almost instantaneously made. During these efforts it is possible that some of the fluid may accidentally enter the upper orifice of the larynx. It is more probable, however, that the result is produced in the following manner. The moment the hot water touches the interior of the mouth, acute pain is felt, and the child is instantly incited to scream. Preparatory to the scream, a sudden inspiratory effort is involuntarily but necessarily made. By this effort some of the boiling fluid, or hot steam from it, may be drawn into or towards the larynx. And thus the upper part of this portion of the air-tube may be scalded, together with the interior of the mouth and fauces. In many cases, however, the larynx itself is not actually scalded, but becomes speedily implicated by extension of inflammation and œdema from the fauces. In other cases spasm of the glottis may be excited, and give rise to the belief that the larynx has been directly implicated in the injury.

Immediately upon the receipt of the injury the sufferer screams violently, and, by instinctively applying both hands to the mouth, indicates the part injured. On examining the mouth, the whole inner surface is found inflamed, swollen, and vesicated, and the soft palate and fauces present similar appearances. This condition of the

[1] Med.-Chir. Trans., vol. xii.

parts is attended by great pain, and difficulty in swallowing, or even total inability to do so. There is more or less hoarseness of the voice. The child becomes restless, and symptoms of inflammatory fever soon appear. Within two or three hours the respiration may become affected. Sometimes a delusive period of prolonged calm follows the injury, and after several hours, almost suddenly gives place to an access of alarming symptoms. Inspiration becomes difficult, and is accompanied by a hoarse croupy sound, and aggravated by occasional attacks of spasm. The difficulty may increase gradually or very rapidly. In many cases the child suffers from frequent vomiting. Unless these symptoms are soon relieved, the face becomes livid, the extremities cold, the respirations more hurried and oppressed, the voice quite lost, and the child gradually sinks into a state of collapse; or death takes place in a fit of suffocative spasm. In some cases the little patients recover from imminent danger within three or four days, or even earlier. In other cases death from suffocation speedily ensues; or if this is prevented by the timely performance of laryngotomy, tracheal or pulmonary disease may prove fatal at a later period.

After death indications of inflammation of the lining membranes of the cheeks, fauces, and tongue are found. These parts are swollen and corrugated; and the mucous membrane is raised into blisters, or covered with whitish patches. There is redness and swelling of the pharynx, and in one case, related by Mr. Gillman,[1] "the œsophagus to within a short distance of the cardiac orifice of the stomach presented the usual appearances of a scald." The mucous membrane of the epiglottis, and the glosso-epiglottidean and aryteno-epiglottidean folds, are thickened, from effusion of lymph into the subjacent areolar tissue. Occasionally this occurs to such an extent as to close the upper orifice of the larynx; but the œdema never extends below the true vocal cords. In case the patient has lived only a few hours, the mucous membrane below the rima may be quite healthy. In case, however, the patient has survived longer, the mucous membrane of the trachea and bronchi is, as a rule, highly inflamed, and occasionally covered by adventitious membrane similar to that produced in croup; or the tubes may be loaded with thick viscid mucus. In such cases the lungs are usually congested, and some of the pulmonary tissue is in a state of hepatization.

The symptoms and post-mortem appearances show that injuries of this kind may cause death by suffocation, either rapidly, from violent inflammation of the larynx, or more slowly, through extension of inflammation to the bronchi and lungs.

Treatment.—The most active antiphlogistic treatment must be employed. Leeches should be applied to the throat in the immediate vicinity of the larynx, the number being proportioned to the age and strength of the patient, and the urgency of the symptoms.

Counter-irritation by blisters applied to the upper part of the chest may be of benefit in some cases.

Calomel may be administered in doses of two or three grains every hour, until the symptoms are relieved, or until the indications of constitutional effects appear. The dose may then be diminished and given at less frequent intervals. The advantage derived from the use of calomel in these cases was first pointed out by Dr. Wallace of Dublin. It has recently been strongly urged by Mr. Croly[1] of Dublin and others. Numerous instances have occurred, in which the exhibition of this remedy has been followed by the most marked relief. It occasionly happens that the patient is unable to swallow: under such circumstances mercurial inunction may be employed. Indeed, Mr. Croly recommends inunction simultaneously with the administration of calomel. I have seen the best results follow the administration of antimony and aconite in small but very frequently repeated doses. One or two minims of the antimonial wine, with a quarter or half a minim of tincture of aconite, may be given at first every quarter of an hour; then every half hour; and subsequently at longer intervals, according to the effect produced.

If the symptoms are not relieved, and suffocation appears imminent, laryngotomy or tracheotomy must be performed. It is impossible to lay down any precise rules as to the conditions under which the operation may become necessary. It must be left to the judgment and discretion of the practitioner to decide, after having taken into consideration each point in the particular case before him. As a general rule, however, in the opinion of most surgeons of experience, it is desirable to delay the operation as long as possible. But the patient must be carefully watched; and the surgeon must be prepared to operate at any moment. It should be remembered that though the operation may relieve the patient from impending suffocation, it has comparatively little effect in subduing the inflammation set up by the injury. It affords rest, however, to the injured part;

[1] Med.-Chir. Trans., vol. xii., p. 9.

[1] British Med. Jour., June 16, 1866. On the same subject, see Sloane, British Med. Jour., January 14, 1866; Bevan, Dublin Quart. Jour., February, 1860.

and saves it from being irritated by the passing breath.

The statistical results of tracheotomy, in cases of scalds and burns of the larynx, are certainly not encouraging. But it must be borne in mind that the accident is at best very dangerous, and it is only in the worst cases that the operation is performed. Out of 28 cases[1] of tracheotomy in scald of the larynx (of which I have notes) 23 terminated fatally.

Scarification of the inflamed and œdematous mucous membrane of the back of the fauces, and about the upper part of the larynx, often affords manifest relief, and never, if carefully performed, can be productive of mischief. The operation may be performed with comparative ease by means of a strong, sharp, curved "needle-in-handle," or a curved bistoury defended to within a sixth of an inch of its point by a strip of sticking-plaster; or, better still, by means of the instrument figured above, designed by Mr. Tudor, formerly of the Dreadnought, and by him named the epiglottome.

Fig. 141.

Fig. 141. The Epiglottome.

The finger of the left hand must be introduced well into the back of the mouth or pharynx, and made use of to defend and guide the point of the instrument. Several punctures may be made into the swollen parts. In some cases it may be possible to use the laryngoscope with advantage.

Injuries of the Larynx from Drinking the Concentrated Acids, and other Corrosive Liquids.

The concentrated acids, and other irritant fluids, are sometimes swallowed with suicidal intent, and at other times are taken accidentlay. If taken intentionally, the fluid may be swallowed without the slightest complaint of uneasiness or pain. Mr. Porter says:[2] "I have known a young girl, after taking sulphuric acid, sit quietly and drink tea with some females, who were afterwards suspected of poisoning her, although the dose had been so powerful that she died in a few hours; and I am aware of a man who took a second glass of the same acid, because he thought the first was not sufficiently quick in dispatching him." In cases of this kind the larynx is seldom injured. Notwithstanding the pain necessarily produced, and the highly irritating nature of the liquid, the determination to swallow it is so great that it passes over the epiglottis, along the œsophagus, and into the stomach, without producing any injury to the upper end of the air-passage. But if the fluid is taken accidentally, the effect may be similar to that produced in cases in which boiling water is taken into the mouth. The presence of the irritating fluid excites such an amount of spasm of the muscles of the pharynx and larynx as entirely arrests its course along the gullet. At the same time instantaneous efforts at expulsion are made, and the fluid may be forcibly ejected through the nostrils and mouth. During these efforts it is possible that some of the fluid may enter the larynx. It is more probable, however, that the fluid is drawn in by a sudden inspiratory effort, excited in the manner suggested in the above account of scalds of the larynx, p. 879.

The post-mortem appearances are consequently liable to differ in these two classes of cases. In instances in which corrosive liquids have been swallowed intentionally, the lips are desiccated, and charred or corroded, and are covered with white patches, or discolored in a manner varying with the nature of the liquid; the tongue is similarly affected, and swollen; the soft palate and fauces are highly vascular; the œsophagus is usually more or less affected throughout its whole extent, everywhere congested, and in places very dark in color; the lining membrane of the stomach is often blackened, and sometimes disintegrated, portions of it lying flocculent and loose. On the other hand, in instances in which these fluids have been taken accidentally, the injuries are for the most part limited to the mouth, fauces, pharynx, and larynx. But sometimes the trachea and bronchial tubes are reached. Indeed, Dr. Gull[1] has recorded a remarkable case in which sulphuric acid passed into and partially destroyed both lungs.

The particular effects and appearances to which different corrosive liquids give rise when swallowed, and the manner in which they are liable to affect the air-passages, are very fully described, and numerous examples are quoted, by Dr. Taylor, in his treatise on Medical Jurisprudence.[2]

In some cases it would appear that in-

[1] Collected from various publications; in Guy's Hospital, or elsewhere under my own observation.

[2] Op. cit., p. 178.

[1] Med. Gaz., vol. xlv., p. 1102.

[2] Principles and Practice of Medical Jurisprudence, by Alfred S. Taylor, M.D., 1865, p. 100, et seq. [8th Am. ed., 1880, p. 106.]

flammation of the larynx, at least to such an extent as to impede respiration, never takes place.

Cases, however, occasionally happen in which very acute symptoms of laryngitis come on very soon after the accident. These symptoms may be the direct result of injury to the larynx itself, or they may be due to extension of inflammation from the injured fauces or pharynx.

If the liquid taken is of a volatile or fuming nature, as ammonia, or nitric, hydrochloric, or acetic acid, the fumes may be inhaled, and give rise to inflammation of the larynx and other parts of the respiratory tract. Many fatal cases of this kind are on record.[1]

Treatment.—The same treatment should be adopted as is applicable to laryngitis from other causes. Leeches and fomentations should be used externally, and calomel administered in small but frequently repeated doses. If the symptoms are not relieved by these means, and suffocation appears imminent, tracheotomy should be performed. In such a case the surgeon operates to rescue the patient from impending death; but the extensive mischief produced by the contact of the poison with the neighboring parts, or more distant organs, generally leads to a fatal issue.

Three cases of this kind in which tracheotomy was performed have recently been under observation in Guy's Hospital. In one case the patient, who had taken strong acetic acid, recovered. In the other two, death resulted from the effects of the injury. In one of these, sulphuric acid had been taken. The parts about the glottis were so swollen as to cause complete closure. In the other case, carbolic acid had been taken. The bronchi were choked with brown thick mucus smelling strongly of the poison.

Foreign Bodies in the Air-passages.

Foreign bodies of the most diverse kinds occasionally enter the air-passages, and imperil or more or less speedily destroy life. Among the foreign substances that have been most frequently found in the air-passages, may be enumerated portions of food, plum and cherry stones, peas, beans of various kinds, acorns, nutshells, melon and pumpkin seeds, ears of grass, grains of corn, portions of bone, teeth, artificial and natural, shells, buttons, button-moulds, pieces of money, musket-balls, shot, and pebbles. A great many other substances, animal, vegetable, and mineral, have been found in rare and exceptional instances: for example, puff-darts, worms, leeches, claws of crabs, etc. In one instance, the larynx of a goose was found; in another, a detached bronchial gland.

[1] Case of Mr. Haywood, Lancet, April, 1854, p. 430. Case of Mr. Stewart, Chemical News, March, 1863, p. 132, etc.

Generally, only one foreign body enters at a time; but cases have occurred in which "two, three, or even four foreign substances have entered the air-tube either simultaneously or successively."[1]

Some foreign substances (vegetable or animal), such as peas, beans, portions of meat, etc., when retained beyond a certain period, are liable to become enlarged by imbibition of moisture; and consequently they may occlude more closely the part of the tube in which they are lodged.[2] Any foreign substance may become coated with inspissated mucus or lymph after remaining long in the air-passage. These facts are of practical importance, since they go to prove that the longer a foreign substance is retained, the greater danger there may be of increased obstruction to respiration.

Liquids, as drinks, medicines, blood, pus, etc., sometimes get into the air-passages. As a general rule, however, they are speedily expelled, and surgical aid is not required. But it may happen that the most serious results may follow if, from any cause, expulsion cannot be quickly effected. In such cases death from suffocation may ensue,[3] or inflammation may be set up. Attention has recently been directed to a class of cases in which suffocation has occurred during sleep, or during drunkenness, and in which, on examination, the air-passages have been found filled with fluid material, similar to that contained in the stomach. In some such cases the lung-tissue has been observed to have been more or less affected by the solvent action of the gastric juice. It has been suggested, in explanation, that vomiting or regurgitation from the stomach may have taken place during unconsciousness; and that, under such circumstances, vomited material may have been drawn by inspiration from the pharynx into the air-passages. Cases of this kind are doubtless very rare, but it is possible they may be more frequent than is commonly supposed.[4]

Modes of entrance.—Foreign bodies which enter the air-passages, usually pass by way of the mouth; but this is not invariably the case (see p. 883).

As a rule, the foreign body is drawn in from the mouth by a strong, sudden, ill-timed or unguarded inspiratory act. Sometimes it may simply fall through the mouth

[1] A large number of interesting and curious cases have been collected together by Professor Gross of Philadelphia, and published, with practical comments, etc., in an elaborate Treatise on Foreign Bodies in the Air-Passages; Phil., 1854.

[2] Gross, op. cit., p. 37.

[3] See remarks on blood in the air-passages in the chapter on Wounds of the Neck.

[4] For cases in illustration, see L'Union médicale, No. 91, 1868: Case of a child, by Dr. J. Parrot. Also Annales d'Hygiène, 1869, p. 471.

into the larynx, as when a person is throwing up and catching a coin in the mouth.

The accident does not happen, as is popularly supposed, during the act of swallowing. But in exceptional instances it may do so; as for example, in cases of paralysis of the muscles of deglutition, and in cases of partial or complete destruction of the epiglottis. Under ordinary circumstances during the process of deglutition the larynx is elevated, and the epiglottis falls over and completely closes its upper aperture; the entrance of the smallest morsel of food is thus effectually prevented.

The accident most frequently happens to persons engaged in talking and laughing while their mouths are filled with food, or contain some foreign substance or other. Preparatory to the act of speaking or laughing, a deep inspiration is necessary: during this the epiglottis is raised; the upper orifice of the larynx is opened; and the margins of the glottis are widely separated. If under such circumstances, the mind is engaged by interesting conversation, or the attention is suddenly attracted, the vigilance of the muscles guarding the aperture of the larynx may not be excited; and any object contained in the mouth may be drawn by the current of inspired air into the larynx or trachea. Sometimes a blow, or unexpected slap on the back, or a sudden desire to sneeze, at once diverts the attention, and incites a strong inspiratory effort.

Many cases have occurred in which projectiles in blow-tubes, or peas or cherry stones in peashooters, have been drawn into the air-passages by careless or unguarded inspirations.

But though the mode of introduction by inhalation from the mouth is the most common, there are various other ways by which in exceptional cases foreign bodies have been known to get into the air-passages. And it may become a matter of some importance in the diagnosis of certain cases to be acquainted with some of these ways.

In some instances foreign bodies pass from the œsophagus and pharynx into the air-passage.

A stout hearty laborer died suddenly whilst eating his Sunday's dinner. On examination, a piece of meat was found in the rima glottidis, and a quantity of masticated beef and cabbage in the trachea and bronchi. It seems probable that the man had filled his stomach to such an extent as to induce vomiting, and that in consequence of his endeavoring to inspire at the moment the food was being rejected, some of it had entered the air-passage.[1]

Again, numerous instances are recorded, both by ancient and modern authors, in which lumbrici have made their way from the stomach into the pharynx, and thence into the larynx and trachea.[1] In some such cases death by suffocation has resulted. Instances have also occurred in which leeches, probably swallowed in drinking-water, have passed from the pharynx into the air-passage. M. Vital relates a case in which a living leech was removed by tracheotomy from the trachea of a soldier.[2]

It occasionally happens that a communication between the œsophagus and trachea results from long-standing ulcerative disease, as epithelioma, etc. In any such case, foreign bodies may pass through the opening, and get into the air-passages. Such cases are not rare. I have seen several, and in some of them tracheotomy has been necessary. Again, foreign bodies may enter through artificial openings, as in wounds of the throat. And sometimes foreign bodies impacted in the œsophagus produce ulceration, and pass through into the trachea.[3]

A case, related by Mr. Edwards[4] of Wolverhampton, affords perhaps the most remarkable illustration on record of the manner in which a foreign body may get into the air-passages, as well as of the extraordinary source from whence such body may be derived. A boy, æt. 8, playing with other boys about his own age, was offended or struck by one of them. He ran off to tell his mother. Just as he got home, thirty yards distance, he seemed to be in a fit. He struggled violently; his head was thrown back; his countenance anxious, his face discolored; and he said once or twice that he should die. He denied having swallowed anything. Tracheotomy was performed in about half an hour, and artificial respiration attempted, but without any beneficial effect. On dissection there was found fixed in the rima glottidis a body about an inch in length. This, on further examination, proved to be a bronchial gland, which had become detached, and had made its way by ulceration through the bronchus into the air-passage. On slitting open the trachea, the ulcerated opening through which the gland had passed was found. Another remarkable instance of a foreign body getting into the windpipe without passing through the rima glottidis is mentioned by De La Martinière.[5] A child, nine or ten years of age, amusing himself with cracking a small whip, was suddenly seized with extreme difficulty of breathing, and soon exhibited all the symptoms of approaching suffocation. The surgeons who saw him did not suspect the existence of a foreign body impeding respiration. He was bled; the throat was examined, and an œso-

[1] Ryland, op. cit., p. 280.

[1] Aronssohn, Arch. de Méd., 1836, tom. x., p. 44.

[2] Gazette médicale, 1838, p. 139.

[3] Bégin, Journal hebdom., quoted with other cases in Diction. encyclopédique des Sci. méd., art. Larynx, pp. 705, 706.

[4] Med.-Chir. Trans., vol. xxxvi.

[5] "Observations sur un corps étranger," etc., in Mém de l'Acad. de Chir., vol. v., p. 521.

pharyngeal bougie passed, without any discovery being made. The symptoms became more urgent, and De La Martinière saw him an hour after. On examining the neck externally, a small red spot was found immediately below the cricoid cartilage. Beneath this was felt deeply, a little circumscribed ganglion, as large as a lentil. It was at once determined to cut on to this spot. On doing so an irregularity projecting a line in front of the trachea was felt. This proved to be due to the presence of a large copper pin, which was at once extracted. The pin was an inch and a quarter in length. It had been fixed in the end of the lash of the whip. The trachea had been pierced through from left to right. The child got well in a few days.

Situation and mobility.—The different situations which the foreign body, however introduced, may occupy, and the manner in which it may become moved from one situation to another, must now be considered. The size, shape, and weight of the body and the mode of introduction often, to a certain extent, determine the situation it occupies, and its degree of fixity.

1. The foreign body may be arrested in the larynx. It may become impacted in the superior aperture, or in the cavity, or in one of the ventricles of the larynx, or it may be lodged and firmly held in the chink of the glottis. Sometimes it may become fixed immediately below the glottis.

2. The foreign body may pass into the trachea, and occasionally, but very rarely, may be arrested there. Generally, however, it descends into one or other of the bronchi, and in the majority of instances into the right one. Instead of becoming fixed, the body may be moved up and down during respiration. Sometimes it may pass from the bronchus into the trachea, and then into the other bronchus. Sometimes it may pass from the trachea up into the larynx, and there become impacted.

3. The foreign body may enter one of the second or third divisions of the bronchus, and there become firmly fixed.

4. At a later period the body, after having excited inflammation and ulceration, may find its way into the lung-substance, where it may become encysted, or may give rise to further mischief.

Out of twenty-one cases analyzed by Professor Gross,[1] in which death took place without operation, and without expulsion of the foreign body, "in four, the foreign substance was situated in the larynx; in one, partly in the trachea, partly in the larynx; in three, in the trachea; in eleven, in the right bronchial tube; in one, in the lung; in one, in the right pleural cavity."

"Out of forty-two cases subjected to operation or general treatment, the extraneous substance was situated twice positively, and eleven times probably, in the right bronchial tube; four times certainly, and four times probably, in the left bronchial tube; seven times in the trachea, and fourteen in the larynx." Out of fifteen cases under observation in Guy's Hospital during the last few years, in seven the foreign body was in the larynx; in five, in the trachea; in two, in the right bronchus; and in one, in the left bronchus. It would thus appear that the larynx and the right bronchial tube are the most frequent situations in which foreign substances are arrested. This conclusion, however, does not precisely coincide with that derived by M. Bourdillat[1] from the analysis of 166 cases. In eighty of these the foreign body was in the trachea; in thirty-five, in the larynx; in twenty-six, in the right bronchus; and in fifteen, in the left bronchus.

A foreign body which is too large to pass the glottis may remain impacted in the upper part of the larynx. A smaller,

Fig. 142.

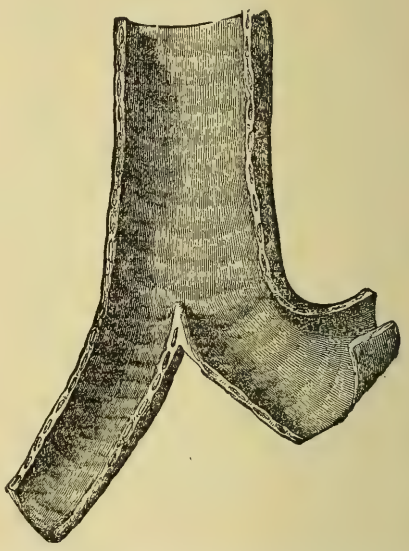


Fig. 142. Bifurcation of Trachea, as seen from behind, the posterior wall removed; showing septum to the left of the median line. From a recent specimen.

light, sharp-pointed or angular body, as a husk of corn, a piece of nutshell, or a portion of apple-core, may often stick in the larynx projecting into one or other ventricle or sacculus.

A foreign body of comparatively large size and irregular in shape, which has passed the larynx, may be impacted in the trachea, and produce more or less obstruction to respiration on both sides of the chest. The heavier the body, the less

[1] Op. cit., p. 419, et seq.

[1] "Des corps étrangers dans les voies aériennes." M. Bourdillat, Gazette médicale, 1861, p. 135.

likely is it to move up and down during respiration. A small smooth body, as a pea or bean, especially if heavy, as a shot or small pebble, is more likely to descend into one of the bronchial tubes than a body less heavy, and more rugged or uneven.

The tendency of the foreign body to pass into the right bronchus rather than into the left, is mainly due to the fact, pointed out by Mr. Goodall, of Dublin, that the septum at the subdivision of the trachea is somewhat to the left of the median line. The larger size of the right bronchus no doubt favors the tendency, though its more horizontal direction may have a somewhat opposite effect.

Symptoms and diagnosis.—The symptoms which immediately attend the entrance of a foreign body into the air-passage are violent spasmodic cough; difficulty of breathing and sense of suffocation; more or less lividity of countenance; and sometimes insensibility. After the first paroxysms have passed off, if the patient survives but the foreign body has not been expelled, the general symptoms are pain about the larynx, trachea or chest; recurrent spasmodic cough; more or less dyspnœa, and sense of oppression; alteration of the voice; expectoration; modified respiration, as evinced by auscultation and percussion; inability to lie in certain positions; and more or less impairment of the general health.

These symptoms vary according to circumstances, and sometimes none of them make their appearance for a very considerable period. Louis gives an instance in which, after the first few minutes, the patient did not experience a bad symptom for a year, at the end of which time he coughed up a cherry-stone, followed by such copious expectoration, that he died exhausted in three days.

When a foreign substance is impacted in the superior aperture of the larynx, or wedged in the rima glottidis, the symptoms depend upon the amount of injury produced, and the extent to which respiration is impeded. Respiration may be impeded either by the mechanical obstruction, or by the spasm excited; consequently, the symptoms vary according to the size and nature of the extraneous body, and the degree of irritation it causes. When the foreign body is large, such as a fragment of food, and firmly impacted, almost instant death takes place from suffocation. It occasionally happens that a foreign body, after having been lodged in the trachea for a variable period, is propelled, in a paroxysm of coughing, into the chink of the glottis, where it may become impacted, and speedily destroy life.

When the foreign substance is in the cavity of the larynx, and its size is insufficient to entirely prevent the passage of air, instant death does not always take place; and the symptoms then produced depend much upon the nature of the extraneous substance. If it is sharp, or angular, the symptoms are usually very severe. Pain is felt in the region of the larynx; there is a constant sense of suffocation, and great distress; violent and very frequent attacks of spasmodic cough occur; the respiration is croupy; and the voice is hoarse or altogether lost. In cases of this kind there is seldom any long-continued intermission of the symptoms; and this circumstance, together with the history of the case, the fixed pain in the larynx, and the absence of morbid sounds on auscultating the chest, indicate the larynx as the seat of the extraneous substance. Unless relief is afforded by the expulsion of the foreign body during coughing, or by operation, death very soon ensues. If, however, the foreign body is small, and smooth, and round, no very severe symptoms may arise for some time.

When the foreign body is lodged in one of the ventricles of the larynx, the effects produced are similar to those noticed in the preceding cases; but they are less severe, and danger to life is less imminent.

A young man was admitted into the Hôtel Dieu, who had suffered for six weeks from severe cough, accompanied by frequent attacks of impending suffocation. Great uneasiness was experienced in the region of the larynx. These symptoms were ascertained to have arisen from a button-mould having passed into the larynx. The trachea was opened, but though the button-mould was felt, it could not be removed by the finger. The cricoid cartilage was therefore divided, and the foreign body was then extracted from the left ventricle of the larynx.[1]

The patient may live a very long time when a foreign body occupies this situation.

Desault[2] reports a case, in which a cherry-stone was lodged in one of the ventricles of the larynx: the patient, who would not consent to an operation, died of laryngeal disease, but not until two years after the accident. Sir T. Watson[3] states that there is one instance on record in which a piece of gold was lodged for years in one of the ventricles of the larynx, without distressing consequences.

The foreign body occasionally passes through the chink of the glottis, and becomes fixed in the lower part of the larynx, or in the trachea, immediately below the

[1] Pelletan, Clinique chirurgicale, t. i., p. 8

[2] Œuvres chir., t. ii., p. 258.

[3] Lectures on the Practice of Physic, 4th ed., vol. ii., p. 436.

cricoid cartilage.[1] In this case comparatively little distress is experienced, after the first symptoms have passed off. Pain and tenderness are felt at the spot corresponding to the position of the body. The voice may be unaffected; but a wheezing, whistling, or croupy sound is heard during inspiration and expiration; occasionally there is entire absence of cough. In one case the patient, a child, laughed, spoke, and ate, as if nothing had happened.

The foreign substance may pass beyond the larynx into the trachea. In such cases the symptoms that arise, after the immediate effects of the accident have subsided, vary with the size, weight, and figure of the extraneous substance, and also with its fixity or mobility.[2] If the body is light, of small size, with no great irregularity of surface, as a cherry-stone, or plum-stone, it may constantly change its position, and thus produce a train of very characteristic symptoms. Paroxysms of cough occur, and are especially violent when the foreign body is driven up against the glottis. The cough is usually harsh, dry, and hard, and occasionally succeeded by a long and sonorous inspiration like whooping cough. During the paroxysms the face is purple, the cheeks are swollen, the eyes protruding, and a quantity of saliva flows from the patient's mouth. The cough is, as a rule, succeeded by intervals of comparative quiet, during which the patient suffers little inconvenience. This want of persistence in the symptoms is liable to mislead the patient's friends, and even his medical attendant. Sometimes the foreign substance, during its movements upwards and downwards, is felt by the patient to strike the walls of the trachea, especially during forced expiration.

If the foreign substance is heavy, it is less likely to be driven upwards towards the larynx in the act of coughing; consequently the inconvenience produced, and the immediate danger, are less than in a case in which the foreign substance is light and freely movable. The ultimate danger, however, is quite as great.

The situation of the foreign body is occasionally indicated by uneasiness or pain, referred to the lower part of the larynx, the front of the neck, or just behind the sterno-clavicular articulation; and this is more severe when the foreign body is rough and jagged. In addition to these symptoms, M. Louis noticed in one case well-marked emphysema on both sides of the neck, just above the clavicle.

If the foreign body is allowed to remain, the symptoms that arise vary greatly in different cases. Death may occur from spasm of the glottis, or from mechanical obstruction in case the body should be propelled upwards into the rima; or rupture of one of the cerebral bloodvessels may be produced during coughing. At a later period the lungs may become congested and emphysematous; or bronchitis, pneumonia, or pleurisy, may supervene. These symptoms occur in some instances very early, in others at more remote periods.

When a foreign body enters one of the bronchi, the symptoms produced, and the extent to which respiration is obstructed, depend upon whether the substance is fixed or movable, and also upon its size, nature and precise position.

If the foreign body is impacted in one of the bronchi, the entrance of air into the corresponding lung is necessarily more or less impeded. In some instances the obstruction is complete. There is then entire loss of respiratory murmur on the corresponding side of the chest. In other instances the obstruction is only partial. The foreign body may not occupy the whole calibre of the bronchus, in which case the vesicular murmur generally is diminished. Or the body may become lodged in one of the primary or secondary divisions, and consequently, there may be entire absence of the murmur over a certain limited space. In almost all cases natural resonance on percussion is preserved. As a rule, the chest, during inspiration, rises less on the affected than on the sound side. The respiration in the unobstructed lung generally becomes puerile. Fixed pain referred to the upper part of the chest, when the substance is immovable, or constant pain, or sense of weight, on one side or the other, may occasionally serve, with other symptoms, to indicate the position of the foreign body. The voice may be hoarse; the respiration may be wheezing; cough, aggravated on deep inspiration, and accompanied by mucous or purulent expectoration, may also occur. Inflammation of the lung, sooner or later, adds to these symptoms; and if the foreign body is not expelled or removed, the expectoration becomes more copious, and ultimately highly offensive, and of a dark color; the cough becomes more troublesome, and aggravated by any exertion or change of position; the patient suffers from disturbed nights, daily paroxysms of fever, and night-sweats: general depression ensues, and death from exhaustion results.

In some rare instances a foreign body may ulcerate its way from one of the bronchi into the lung-substance. In such

[1] See cases recorded by Mr. Cæsar Hawkins in Med.-Chir. Trans., vol. xxiii., p. 99; and one by Mr. Bullock, Med. Gazette, vol. xvlii., p. 952.

[2] See a paper by Sir B. C. Brodie, Bart., Med.-Chir. Trans., vol. xxiii., p. 286. This paper contains the particulars of the celebrated case of Brunel.

cases the symptoms depend upon the amount of irritation and inflammation set up. Sometimes the body may become encysted, and for years produce little or no inconvenience. But sooner or later it is liable to become a centre of mischief: the neighboring parts become inflamed; the new encysting material (if there be any) breaks down; suppuration takes place; and various symptoms, and physical signs more or less resembling those of pulmonary phthisis present themselves; and death usually but not invariably results from exhaustion.

Diagnosis.—To diagnose with certainty the presence of a foreign body in any part of the air-passages is often a matter of very considerable difficulty, and requires the utmost care and vigilance on the part of the surgeon. Some of the symptoms above detailed may, in certain cases, be absent; none of them are absolutely pathognomonic; and similar symptoms may arise from various other causes.

Laryngoscopical examination affords the means, and the only means, by which in some cases a certain diagnosis can be made. If the foreign body can be seen all doubt is at an end. But in very many instances this is impracticable or impossible, at any rate during the earlier periods. If the foreign body is in the larynx, the symptoms are often so urgent as to admit of no delay, or so severe as to render the patient unmanageable. If the foreign body is in the trachea, there is very little probability of its being seen; and if in one of the bronchi, none at all. Laryngoscopical examination should always be attempted when practicable, and while the urgent symptoms are in abeyance. Several cases have already occurred in which, under such circumstances, foreign bodies have been recognized and removed.

Foreign bodies impacted in the pharynx or upper part of the œsophagus, by pressing upon the larynx, or by exciting spasm of the laryngeal muscles, may cause death by suffocation.[1] Such cases must be distinguished from those in which the foreign substances are in the air-passages. [Occasionally the epiglottis and surrounding parts are so much irritated by sharp foreign bodies which have passed down the œsophagus, as to give rise to the belief that the foreign body has actually entered the air-passages; a case of this kind recently presented itself at the Germantown Hospital, Philadelphia. A man was supposed to have in his larynx or trachea a large tack; he had very alarming symptoms, and Dr. Hunt, the consultant, was sent for to perform tracheotomy. He decided to wait, as the symptoms had then in a measure subsided; forty-eight hours afterwards the patient passed by rectum the tack, which measured about an inch in length, and was sharply pointed.] The passage of a bougie may be all that is required in the former condition; in the latter this is useless, or may do mischief.

Foreign substances sometimes get into the air-passages of persons who are eating while in a state of intoxication. In such case the symptoms produced are liable to by mistaken for those of an apoplectic seizure. Mr. Porter[1] has examined seven cases in which death occurred from suffocation in this way; and a similar instance is recorded by Dr. L. Beale.[2]

Cases occasionally come under the notice of the surgeon in which foreign substances are suspected to be in the air-passages, although the attendant symptoms actually depend upon laryngitis, œdema glottidis, croup, laryngismus, rabies, or spasm of the glottis connected with ulceration of the larynx or trachea, or upon aneurism of the aorta pressing on the trachea or bronchial tubes, or upon pressure of a tumor on the laryngeal nerves. Other cases occur in which foreign substances really exist in the trachea, although the symptoms are believed to be dependent upon an attack of croup, or other inflammatory affection of the air-passages,[3] or even to be due to tubercular phthisis.[4]

As an instance of the former class of cases may be mentioned that of a boy, æt. 3, admitted into St. George's Hospital in the year 1851. A small button with which he had been playing was supposed to have slipped down his throat; he had been previously in good health, and continued so for three days after the supposed occurrence. Difficulty of breathing then came on at intervals, with convulsions, foaming at the mouth, lividity of the countenance, a croupy sound during inspiration, and a partial loss of voice. Emetics had been used without relief; and calomel, with Dover's powder, was ordered, which produced vomiting; but no button was expelled. The symptoms continued. The larynx was examined by the finger, but no foreign body was felt. Subsequently laryngotomy was performed, and several explorations were made with various instruments, but no extraneous substance could be found. The dyspnœa and croupy sound continued at intervals; and on the following morning a sudden fit of spasm occurred, which ended fatally. No foreign substance was found

[1] See below, on Foreign Bodies in Pharynx and Œsophagus, pp. 903, 905. Also, Stokes, On the Diagnosis and Treatment of Diseases of the Chest, Dublin, 1827; Habicot, Mém. de l'Acad. de Chirurgie, t. xii., p. 243, ed. in 12mo.; Desault, Œuvres Chirurg., t. ii., pp. 246, 248.

[1] Dublin Medical Press, Feb. 9, 1859.

[2] Path. Trans., 1851–52, p. 250.

[3] Numerous cases illustrating the difficulty of diagnosis are quoted by Gross, op. cit. See also Mém. des Corps Etrangers dans les Voies Aeriennes, Dr. Bertholle, Paris, 1866.

[4] Gross, op. cit. See also Gaz. Méd., 1868, p 701, for a recent illustration of this error.

in the air-passage after death. There was a little lymph upon the mucous membrane of the glottis; the mucous membrane lining the trachea and bronchi was very vascular, and the bronchial tubes contained much muco-purulent fluid.

As an illustration of the latter class of cases in which the foreign substance may be present, but the attendant symptoms taken for those of croup, Mr. Henry Gray records the following case. "I once saw a little boy suffering from such urgent dyspnœa that it was necessary to open the trachea. The symptoms came on, according to his mother's account, on the disappearance of a cherry-stone, with which he had been playing; but they simulated those of croup so closely that no further attempt was made to search for a foreign body. The boy died; and, after death, I found the cherry-stone in the trachea."[1]

Again, a foreign substance may enter the air-passage at the moment that a blow or other injury is received, or at the commencement of a fit. Under such circumstances the difficulty of breathing which follows is not unlikely to be attributed to the effects of the injury or fit, and the real cause may be altogether overlooked.

A child playing in the street was struck by the shaft of a jaunting car. The bystanders declared that the wheel passed over her breast. She so far recovered in a few minutes as to be able to walk home. But her breathing was croupy; she suffered from intermittent cough, and incessant restlessness. At the end of about thirty-eight hours she had a paroxysm of convulsive cough. She flung her head on the pillow, and was dead in an instant. On post-mortem examination a portion of an almond-shell was found in the larynx, with its rough broken edge in the rima glottidis. No trace of injury to the thorax could be discovered. Mr. Porter[2] remarks: "In this case, the existence of a foreign body in the larynx or trachea had never been suspected. Nor am I aware that any symptom observed could have warranted such a supposition. It was considered as difficult breathing resulting from injury of the neck or chest."

Such cases as those to which allusion has thus been made, and very many more that might be quoted, serve to show that there may be very great difficulty in forming an accurate diagnosis.[3] Extreme care, therefore, is requisite on the part of the surgeon in every case in which the symptoms are such as may be due to the presence of a foreign body in the air-passage. Inquiry should be made into the previous history of the patient, especially as to the existence of any chest or throat symptoms before the supposed accident. Inquiry should also be made as to the probable presence in the mouth of any foreign substance; and the size and shape of any such substance should be, if possible, ascertained.

Cases in which foreign bodies are in the air-passages may be distinguished from those in which respiration is obstructed by foreign bodies in the pharynx or œsophagus, by the comparative facility with which deglutition is accomplished in the former cases, and the difficulty generally experienced in the latter. The differential diagnosis may be generally established by examination with the finger, or by passing a probang down the œsophagus. In any doubtful case the probang should be passed without hesitation. If the foreign body should be in the food-passage, not only will the diagnosis be made, but relief may be at once afforded. And if the foreign body should prove to be in the air-passage, no harm is likely to arise from the exploration of the gullet.

The symptoms due to the presence of a foreign body in the air-passage may be distinguished from those of croup or laryngitis by the sudden severity with which they make their appearance, and the absence of all premonitory indications. In the former case, also, there is at first little or no pyrexia, and the difficulty of breathing is intermittent. Severe paroxysms come on at intervals, and then for a time subside. The dyspnœa is especially marked during expiration; the reverse of this is observed in laryngitis. At a later period, when inflammation is established, the ordinary symptoms of laryngitis of course present themselves; and in some cases even false membranes, similar to those of croup, may, as already stated, be formed.

Bronchitis, pneumonia, pleurisy, and phthisis may all arise in consequence of, or in association with, the retention of foreign bodies during prolonged periods. The exact diagnosis in such cases is generally a matter of extreme difficulty. Very numerous cases are on record in which mistakes have been made.[1]

Results.—The results that may follow the entrance of foreign bodies into the air-passages have been already indicated. They may, however, be recapitulated with a few additional observations.

1. The foreign body may be expelled through the glottis, either immediately after its entrance, during a fit of coughing, or at some subsequent period, with or with-

[1] Former edition of this work. A somewhat analogous case is recorded by Dr. Conway Evans in the Edin. Med. Journal, 1860, p. 626. See Holmes, Surgical Treatment of Children's Diseases, 2d edit., p. 295; also Limousin, quoted by Bertholle, op. cit., p. 79, for similar examples.

[2] Op. cit., p. 193.

[3] Upon this point, see Holmes, op. cit., p. 295.

[1] See p. 887. Also, Bertholle, op. cit., p. 84 et seq.; Bourdillat, "Des Corps Etrangers dans les Voies Aeriennes," Gaz. Méd., 1868, pp. 96, 121, 122. This article, continued through several numbers of the Gaz. Méd., contains much information, and analyses of a great number of cases.

out having produced serious structural lesions.

The period at which expulsion may take place varies greatly, as will be seen from the following summary of 124 cases, in each of which spontaneous expulsion took place, and recovery ensued:

Period of Expulsion.	No. of Cases.
Immediately, or in less than 24 hours	5
In from 1 to 8 days	11
" 8 to 30 days	16
" 30 days to 1 year	64
" 1 year to 17 years	28
	124

Professor Gross quotes a very remarkable case (not included in the above summary) in which a portion of bone is stated to have been expelled after having been retained during a period of sixty years. Recovery followed.[1]

2. Death may occur almost immediately after the entrance of a foreign body, from suffocation, or at a subsequent and very variable period from the same cause; or fatal hemorrhage may ensue, as in Rokitansky's[2] case, in which a small dart, drawn into the trachea, was forced into the innominate artery during a fit of coughing. In some cases in which the foreign bodies have been expelled, death from exhaustion or from some other cause has nevertheless resulted.

3. Various structural lesions of the most serious and often fatal character may be produced. For example, inflammation and œdema, or ulceration of the mucous membrane of the larynx may be set up if the body is retained in the upper part of the windpipe; or if it has descended lower, inflammation of the lung-tissues, followed by consolidation, or suppuration, ulceration, or gangrene, may be caused. Sometimes the lung-substance is traversed, and the pleura reached. In such cases empyema occurs.

A good illustration is afforded by the case recorded by Mr. Carpenter[1] in which a set of four false teeth, made of one piece of ivory, had been drawn into the air passage. Thirteen years afterwards the patient died after an attack of acute pleurisy. The right pleural cavity contained five pints of sero-purulent fluid, and in it were found the artificial teeth. A fistulous opening was observed on the surface of the lung, through which it was supposed the teeth had passed.

In some cases pulmonary emphysema results. In others the foreign body seems to serve as a nucleus around which tuberculous deposit may take place.

4. In some rare instances foreign bodies, known to have entered the air-passages, have been discharged, long afterwards, through abscesses or fistulous openings in the thoracic parietes.

5. Results more or less successful may follow surgical interference; or death may ensue, even though the foreign bodies have been removed.

As a general conclusion to this part of the subject, it may be definitely and decidedly asserted that life is in peril so long as a foreign body of appreciable size is retained in any part of the respiratory tract. At the same time, it is very uncertain at what period danger may become imminent, and in what way it may arise.

If this be true, it is obvious that the surgeon should lose no time in adopting such measures as may secure the safety of the patient, and aid the removal or expulsion of the foreign body.

The following carefully compiled summary of 554 cases must be taken for what it is worth, but it certainly seems to furnish a strong argument in favor of operative measures. It should be premised that no case is included in which death or expulsion immediately followed the accident.

Result of Cases of Foreign Bodies in the Air-Passages.

1. *Cases in which no operation was performed:* Result.	Total No. of Cases.	Recoveries.	Deaths.
Death without expulsion of foreign body	95		95
Spontaneous expulsion of foreign body	164	149	15
Expulsion after emetics (recorded as useless in 46 cases)	5	5	
Discharge at late period through thoracic abscess	7	2	5
Total of cases not operated upon	271	156	115

[1] Gross, op. cit. p. 172, quoted from New York Journal of Medicine, vol. vi., p. 23.

[2] Pathological Anatomy, vol. iv., p. 37 (translated by Day for the Sydenham Society).

[1] Guy's Hospital Reports, 1st Series, vol. vii., p. 353.

RESULTS OF CASES OF FOREIGN BODIES IN THE AIR-PASSAGES—(*Continued*).

2. *Cases in which operative measures were adopted:*	Total No. of Cases.	Recoveries.	Deaths.
OPERATION.			
Laryngotomy, followed by expulsion	14	13	1
" not followed by expulsion	3		3
Tracheotomy	231	170	61
Laryngo-tracheotomy	20	15	5
Direct extraction	3	3	
Inversion of body and succussion	12	12	
Total of cases operated upon	283	213	70
Total number of cases, operated upon, or not	554	369	185

It would thus appear that in the cases above summarized in which no operation was performed, death resulted in about 42.5 per cent.; and recovery in about 57.5 per cent. On the other hand, in the cases in which operative measures were resorted to, death resulted in about 24.8 per cent.; and recovery in 75.2 per cent. The general result, therefore, is greatly in favor of operative measures.

Treatment.—When a foreign body is known to be retained in some part or other of the air-passage, the promptest treatment is demanded. The surgeon should not trust to the unaided efforts of nature to expel the extraneous substance, nor should he for an instant leave the patient unwatched until safety is assured. Temporizing measures should never be persisted in when once the means of affording effectual relief are at hand. Emetics, sternutatories, and such like "remedies" should not be administered. They are almost certain to increase the distress of the patient, and they are not likely to be productive of any good result.

If the circumstances of the case permit, attempts may be made to detect the foreign body, by aid of the laryngoscope, and to remove it by direct extraction.[1] In very many instances, however, in which the foreign body is in the larynx, the symptoms are so urgent that no time is to be lost. It is necessary, therefore, to defer the laryngoscopical examination until the safety of the patient has been insured by opening the windpipe.

Inversion and succussion of the body of the patient have proved successful in some few cases; but in many more, this method has been tried in vain;[2] and as in the case of Brunel, it has frequently caused much distress.[1] It cannot be considered as altogether free from risk, and should not be attempted unless the surgeon is prepared to open the windpipe at once in case of need. When the patient is inverted, the foreign body may fall from the trachea into the larynx, and there become arrested. In such case occlusion of the glottis and instant suffocation may ensue.

As a general rule, the windpipe should be opened with as little delay as possible in every case in which a foreign body is certainly known to be retained in any part of the air-passage. By this means the immediate safety of the patient is secured, and the subsequent expulsion or removal of the foreign body is aided. In some cases there is not a moment to lose; the windpipe must be opened at once. Sometimes the patient may cease to breathe before this is accomplished. The operation should nevertheless be completed, and artificial respiration instituted and perseveringly maintained. In other cases there is ample opportunity for the administration of chloroform [or ether], which should always be given if practicable; and the surgeon may operate with deliberation. In other cases, again, the symptoms may be so slight that the surgeon may be inclined to hesitate before adopting such severe treatment as that recommended. But there is great danger in delay. An interval of calm constantly precedes the recurrence of urgent symptoms. Temporary freedom from distress must not be regarded as contraindicating the operation, but rather as affording the best opportunity for its performance. If the surgeon hesitates to operate under favorable circumstances, he may be compelled to do so in the greatest haste and under the greatest difficulties. In such case his chance of success is comparatively small. Opening the windpipe cannot be considered in itself a dangerous operation, if performed with due deliberation and care. The risks asso-

[1] See case by Gibb, Lancet, 1864, vol. i., p. 39.

[2] Gross, op. cit., p. 205. Numerous examples.

[1] Med.-Chir. Trans., vol. xxvi., p. 286.

ciated with it depend rather upon the conditions which render it necessary, or upon the ill effects of the retention of the canula in the air-tube. Such risks are proved by experience to be considerably less when the operation is performed on account of the presence of a foreign body, than they are when it is performed on any other account. The expulsion or extraction of the foreign body, if effected early, at once removes the great source of danger; and there is rarely any necessity for the prolonged retention of the canula, if even it has been found necessary to introduce it for a time.

The part of the windpipe which should be opened depends upon the position which the foreign body is believed to occupy; and also to a certain extent upon the age of the patient, and the size and character of the extraneous substance.

When the symptoms indicate that the foreign body is in the larynx, laryngotomy should be performed. First, because in such cases the symptoms are, as a rule, most urgent, and this operation is perhaps the most easily and most quickly performed; and, secondly, because an opening through the crico-thyroid membrane is near to the foreign body, and consequently is favorably situated for future proceedings. A large opening should be made at once. If the patient is very young, and the crico-thyroid space does not permit an opening of satisfactory extent, the incision may be carried downwards, and the operation of laryngo-tracheotomy accomplished. It frequently happens that the full access of air to the lungs, thus afforded, enables the patient to expel the foreign body at once, either through the glottis, or through the opening made. If expulsion should not immediately take place, the best plan is to introduce a canula and wait awhile. In the course of a short time the spasmodically contracted muscles of the larynx may become relaxed; and the foreign body being thus set at liberty, may be expelled. The canula secures freedom of respiration; and by its pressure serves to arrest hemorrhage, and to prevent the entrance of blood into the air-passage. When the patient has recovered from the immediate effects of the operation, if the foreign body still remains unexpelled, attempts may be made to dislodge it by removing the canula and exploring the larynx by means of a probe or catheter. Great care is necessary in doing this.

A case came under my observation some time ago in which a probe was repeatedly passed through the larynx up into the mouth, and the finger was also passed down through the mouth into the larynx, but no foreign body was discovered. The child seemed free from all distress, and breathed well through the larynx. It was supposed that the foreign body had been dislodged and coughed up, although it could not be found. In the course of a few hours symptoms of suffocation suddenly came on, and before assistance could be rendered the child was dead. On examination a piece of apple-core was found in the rima glottidis, sticking across from one ventricle of the larynx. Several similar cases have been recorded.

If the foreign body is small and smooth and flexible, it may easily escape detection by a probe. A larger instrument should be used. The upper end of an elastic catheter may be recommended. The small ivory cap, with its flat top and hole in the centre, renders this instrument well adapted for the purpose; but it must be used with care.

After laryngotomy has been performed, and while the patient is breathing freely and safely through the canula, laryngoscopical examination may be made under favorable circumstances. If the foreign body is seen, it may be extracted by forceps, such as represented in FIGS. 143 and 144.

In some cases, Mackenzie's Laryngeal Forceps (FIG. 145) may be advantageously used. The stem of this instrument is so slender as not to obscure the view. The blades (*b*) are so arranged that they can be turned by the screw (*a*), so as to open in any direction. They are closed by pressure upon the trigger (*c*).

Forceps constructed after the method of Messrs. Robert et Collin (of Paris) are very suitable. This method of construction is illustrated by FIG. 156 on page 908.

If the foreign substance cannot be extracted by such means, inversion and succussion of the patient may be tried. There can be no risk in making the attempt after the larynx has been opened; and in some instances success has resulted. The celebrated case of Brunel, to which reference has already been made, affords an excellent illustration. This method is most likely to prove successful if the foreign body is smooth, rounded, and heavy, as a piece of money, a shot, or a bullet.

But it may happen that the foreign body still remains fixed in the larynx after full opportunity has been afforded for its expulsion, and fair trial has been given to the several modes of treatment already specified. In such case the surgeon should not hesitate to cut through the thyroid cartilage (*thyrotomy*). The interior of the larynx may be thus fully exposed, and the foreign body certainly found and removed. The incision through the thyroid cartilage should be carried perpendicularly upwards from the opening in the crico-thyroid membrane already made, and should be strictly in the middle line; it may also be extended downwards if needful, through the cricoid cartilage (*crico-thyrotomy.*) This operation may be performed perhaps somewhat more advantageously if the trachea rather than

the larynx has previously been opened. In the former case the tracheotomy canula may be more readily retained during the operation, and the entrance of blood into the air-passage more easily prevented. Such at least has been my own experience. There is no difficulty in the performance of this operation, and there would not appear to be much risk involved. I find on record twelve successful cases, and not one in which death resulted. In some of the cases the voice has been more or less permanently affected, but in none of them to a serious extent. A similar operation has been repeatedly performed for the removal of morbid growths in the larynx, but with somewhat less uniform success.[1]

The period at which this operation should be performed must depend upon the circumstances and conditions of the particular case under consideration. As a general rule, the earlier it is done the better chance is there of complete success; the longer the foreign body is allowed to remain in the larynx, the more likely is it to set up inflammation, ulceration, and other structural lesions. I have performed this operation twice with the most successful results. In each case, however, there can be no doubt that if the operation had been performed much earlier than it was, the patient would have been spared considerable suffering and many risks.[1]

After the foreign body has been extracted, the edges of the incision through the thyroid cartilage may be brought together and secured by suture. It may be well to retain the laryngeal or tracheal canula for two or three days, or until all indications of laryngeal mischief have passed away.

When the symptoms indicate that the foreign body is in the trachea or one of the bronchi, tracheotomy should be performed. The opening made into the air-tube should be of considerable extent, and as low down

Fig. 143.

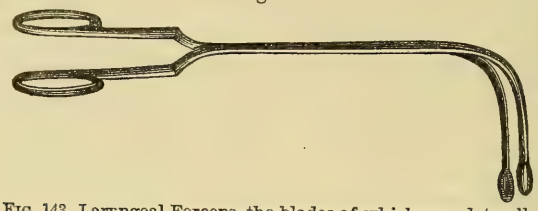


Fig. 143. Laryngeal Forceps, the blades of which open laterally.

Fig. 144.

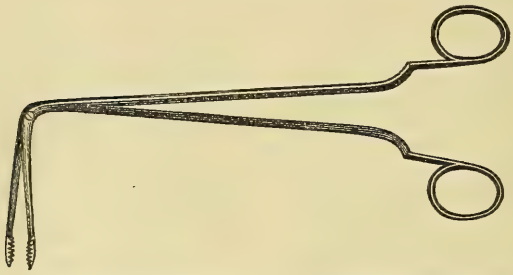


Fig. 144. Laryngeal Forceps, the blades of which open antero-posteriorly.

Fig. 145.

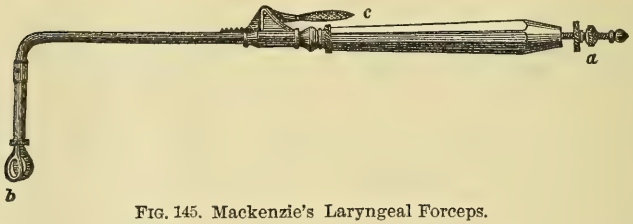


Fig. 145. Mackenzie's Laryngeal Forceps.

[1] Upon this subject, see an excellent monograph by Dr. Charles Planchon, De Laryngotomie, Paris, 1869. Also Durham, "Cases of Operation on the Larynx," Guy's Hospital Reports, 3d Series, vol. xii., p. 540. Also Holmes, op. cit., pp. 298, 311.

[1] Op. supra cit., pp. 544–5.

as practicable. Hilton[1] recommends that a transversely valvular opening should be made. It has been suggested that a portion of the trachea should be cut completely out. Such a proceeding can never be necessary, and if adopted is not unlikely to be followed by serious consequences at a later period. The edges of the opening, whether simply longitudinal or valvular, should be held well apart by means of blunt hooks, or bent wires, or dressing-forceps, or some such dilator as that represented in FIG. 146. Or silk or wire ligatures may be passed through each edge of the wound and tied behind the neck of the patient. In many cases the foreign body is immediately expelled through the opening, and sometimes with very considerable force. If immediate expulsion does not take place, the effect of inversion and succussion may be tried. If this should fail, it is generally better to wait for a time, the patency of the opening in the trachea being secured.

Fig. 146.

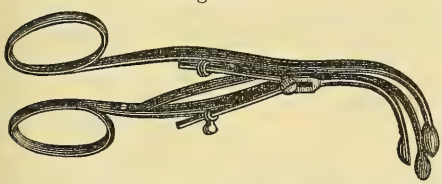


FIG. 146. Laborde's three-bladed dilating Forceps, as modified by Luer, and improved by Mayer and Meltzer.

In some cases a canula may be introduced with advantage, and the patient allowed to recover thoroughly from the immediate effects of the operation. It cannot be too constantly borne in mind that in a large proportion of the cases that have done well, expulsion has not been effected until some time after the operation.[2] The surgeon therefore should neither feel disappointment, nor regret what he has done, even though the foreign body should not be speedily ejected, and the first attempts at removal should utterly fail.

If the foreign body is still retained after full opportunity for expulsion has been afforded, attempts may be made to detect and remove it by means of properly curved forceps, introduced through the opening, and directed upwards or downwards according to circumstances.

The forceps of Professor Gross (FIG. 147) are well adapted for such a purpose: they are long and slender, and made of German silver, so that they can be bent to any degree, and in almost any direction that may be requisite. In some cases snares made of looped wire have been advantageously used. The introduction of any instrument into the trachea, or either of the bronchi, usually excites violent convulsive cough, with heaving of the chest and lividity of the face. The violent cough excited sometimes leads to the expulsion of the foreign body, or drives it between the blades of the forceps.

If the foreign body is comparatively large, and is impacted in the upper part of the trachea, it is better to introduce a canula into the tracheal wound, and to wait until all spasm has had time to subside, and the parts are in a less irritated condition. If the foreign body is comparatively small and is situated in the lower part of the trachea, or has become impacted in one of the bronchi, it is better to lose no time in attempting to extract it by means of the forceps. Some substances, such as peas, beans, etc., may swell by absorption of moisture, and thus become more firmly impacted.[1] And others, as pebbles, shot, etc., by reason of their weight and hardness, may soon find their way on into one of the third bronchial divisions, and thus get hopelessly beyond reach.

The following summary of 167 cases in which tracheotomy was performed on account of the presence of foreign bodies in the air-passages, may serve to indicate to a certain extent the general results that have hitherto attended the operation in such cases. The careful consideration of individual cases supplies still stronger arguments in favor of the operation, and goes to show that in most of the fatal cases death was due in no respect to the operation, but to delay in its performance, or to some failure or deficiency in the measures subsequently adopted.

Fig. 147.

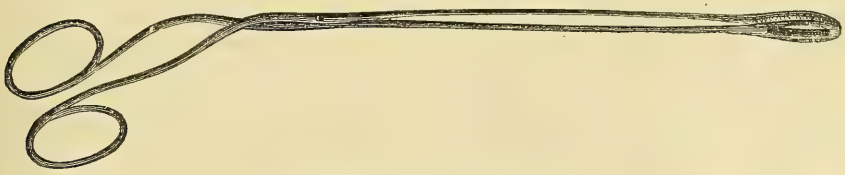


FIG. 147. Gross's Tracheal Forceps.

[1] See Medical Times and Gazette, 1867, p. 507.
[2] See table 496.

[1] See in illustration a case by Mr. Bryant, Guy's Hospital Reports, 3d Series, vol. vi., p. 14.

RESULTS OF TRACHEOTOMY ON ACCOUNT OF FOREIGN BODIES IN THE AIR-PASSAGES.

1. *Cases in which recovery took place:*	No. of Cases.	Totals.	Totals.
MODE AND PERIOD OF EXPULSION OR REMOVAL.			
Spontaneous expulsion through the tracheal opening:			
a. Immediately after the operation	39		
b. Within 24 hours	13		
c. At some subsequent period	10		
Total cases of expulsion through tracheal opening		62	
Spontaneous expulsion through the mouth:			
a. Immediately after the operation	13		
b. At some subsequent period	16		
Total of cases of expulsion through mouth		29	
Removal by forceps, etc.:			
a. Immediately after the operation	31		
b. At some subsequent period	8		
Total of cases of removal by forceps, etc.		39	
Total number of cases in which recovery took place			130
2. *Cases in which death occurred:*			
RETENTION, EXPULSION, OR REMOVAL OF FOREIGN BODY.			
Retention until death	32	32	
Expulsion:			
a. Through the mouth, immediately after the operation[1]	1		
b. Through the opening, immediately[2]	2		
Removal by forceps[3]	2		
Total cases of expulsion or removal		5	
Total of cases in which death occurred			37
Total number of cases analyzed	167	167	167

BRONCHOTOMY.

Under the general term *bronchotomy*, are included the several operations named respectively, laryngotomy, laryngo-tracheotomy, and tracheotomy. In each of these an opening is made into the windpipe, either to afford relief in case of obstructed respiration, or to facilitate the expulsion or extraction of a foreign body, or the removal of a morbid growth. Each operation has its own peculiar merits and advantages, difficulties and dangers, and shares others which are more or less common to all three.

In deciding which operation to perform, the surgeon must be guided in every case by the particular conditions which render the operation necessary, and also by the age and development of the patient. Laryngotomy is by far the easiest operation to perform, and its execution is attended by least risk; but it is not so generally applicable as the others, and it may involve subsequent as well as immediate damage to the vocal apparatus. Laryngo-tracheotomy is easy in execution, and not accompanied by any immediate source of danger; but it is liable to be followed by more or less permanent impairment of the voice, from the injury necessarily inflicted on the cricoid cartilage and parts therewith connected. Tracheotomy is comparatively difficult to perform, and during its performance dangers may have to be encountered greater and more numerous than those met with in either of the other operations; but it is

[1] Death seven days after from broncho-pneumonia.

[2] Death in one case forty hours after operation, from convulsions; in the other, eight months afterwards, from pulmonary disease.

[3] In one case the patient did not rally; in the other, death occurred fifty-three hours afterwards, from blood getting into the trachea.

by far the most generally applicable, and when once safely accomplished, is least likely, perhaps, to be followed by permanent ill effects.[1] But, as before said, the operation to be performed must be decided in each case by the conditions which render such an operation necessary, and the particular collateral circumstances. That which would be the worst operation in one case, may be clearly indicated, nay, absolutely demanded, in another.

Whichever operation may be selected, chloroform should always be administered when practicable. [Ether, properly administered, is quite as satisfactory as chloroform in these cases; although it cannot, from its inflammability, be employed in connection with any form of cautery.] In a very large majority of cases it renders respiration easier by allaying spasm: it thus increases the safety of the patient, and relieves the surgeon from the demand which might otherwise arise for dangerous haste in the accomplishment of the operation.

In cases, however, in which suffocation is imminent from sudden obstruction the administration of chloroform is inadmissible. And it is unnecessary if the patient is already almost or entirely insensible from slow asphyxiation.

Again, whichever operation is to be performed, the patient, under the influence of chloroform or not, must be securely held in proper position before the knife is used. This is especially requisite if the opening is to be made into the trachea.

The patient should lie upon the back. A good firm pillow should be placed under the shoulders and upper part of the chest. The head must not be supported, nor propped forwards by any pillow, but must be thrown well back, and kept perfectly straight until the operation is completed. The chin must be elevated. The shoulders should be drawn downwards. This may be effected in the adult by traction upon the upper extremities; but in the child it is better to make use of a shawl or towel, arranged behind the shoulders, and carried on each side over the acromion and upper extremity, then crossed in front, and finally securely fastened behind and below. A small firm pad should be placed under the neck in such a way as to maintain or increase, as far as practicable, the anterior convexity of the cervical spine, and thus to throw the windpipe forward. By such means, future proceedings are greatly facilitated. When the patient is in the position described, it is comparatively easy to recognize by the touch the several parts which serve as guides to the surgeon in the operations under discussion. These parts are the thyroid cartilage, the crico-thyroid membrane, the cricoid cartilage, the upper part of the trachea, and the isthmus of the thyroid body. The precise situation of each of these should always be distinctly made out, if possible, before the knife is used. But it is often very difficult to do so, especially in the case of a young short-necked, fat child. It has happened that the opening has been made through the thyro-hyoid membrane or through the thyroid cartilage instead of at the spot intended.[1] In the adult subject it is generally easy enough to make out the several parts mentioned, with the exception sometimes of the thyroid isthmus, the position of which, however, can be readily estimated if the cricoid cartilage is distinctly felt. The notch in the upper border of the thyroid cartilage may serve to indicate the middle line of this structure when its median ridge is not recognizable. The middle points of the lower jaw, the thyroid cartilage, and the upper border of the first piece of the sternum, give the line in which, in all of these operations, the incisions are to be made, and from which they should never deviate.

Laryngotomy.—In this operation the opening into the windpipe is made through the crico-thyroid membrane. The operation is simple, easy, and free from risk. It is performed as follows:

Chloroform having been administered or not, the patient is put into proper position, and the precise situation of the crico-thyroid space is ascertained. The larynx is then steadied between the fingers and thumb of the left hand of the operator, and the skin to be incised is at the same time rendered moderately tense. A perpendicular incision, an inch or more in length, is next made in the middle line through the integuments over the lower half of the thyroid cartilage, the crico-thyroid space, and the cricoid cartilage. The fascia between the two sterno-hyoid muscles, and the areolar tissue are then divided, and the crico-thyroid membrane is exposed. The knife is then passed at once through this membrane, and the mucous membrane which lines it, into the larynx. Care must be taken to penetrate the mucous membrane effectually. When this is done, air, blood, and mucus are immediately and forcibly expelled in such a manner as removes all doubt.

The opening may be enlarged transversely to the extent necessary or desirable. Dur-

[1] On the comparative merits of these operations, especially in childhood, see the chapter on Tracheotomy in Holmes's Surgical Treatment of Children's Diseases, 2d edit., p. 312, et seq. Also Mr. Marsh's article on Tracheotomy, St. Bartholomew's Hospital Reports, vol. iii., pp. 337, 338.

[1] Marsh, op. cit. p. 349.

ing the course of the operation the edges of the wound may be held apart by retractors, and bleeding vessels may be secured. The only vessels at all likely to give rise to troublesome hemorrhage are the crico-thyroid arteries (branches of the superior thyroid), which anastomose over the crico-thyroid membrane, and which are very liable to be wounded. Cases are recorded in which serious and even fatal hemorrhage has occurred from these vessels.[1] As a general rule, however, they are easily secured, if needful, by ligature or torsion. Unless the symptoms are very urgent, it is desirable to arrest all hemorrhage before opening the windpipe. When an opening of sufficient extent is made, the canula is introduced. There is rarely any difficulty in doing this, if a blunt pilot trocar is used. But care must be taken to ascertain that the canula is actually in the air-passage. Cases have occurred in which the canula has been passed down into the loose connective tissue in front of the windpipe instead of into the cavity of the larynx. Mr. Gray[2] refers to an instance in which the canula was pushed down between the crico-thyroid membrane and mucous membrane, the latter not having been penetrated at all. The forcible ejection of air, blood, mucus, etc., *through* the canula (not by the side of it) unmistakably indicates that it has been properly introduced. The canula should be secured in position [by stitching it to the adjacent skin by a single silver suture, or it can be retained] by means of soft tapes,[3] passed round the neck and tied. Or the elastic band, furnished with hooks, especially designed for this purpose, may be used. The tapes should always be attached to the canula previous to its introduction. The canula should be of uniform calibre throughout, and furnished with an inner tube. It should be oval (not circular) in section, and curved on the flat. Most laryngotomy canulas are made unnecessarily long.

Laryngotomy is not applicable in early childhood, on account of the very limited dimensions of the crico-thyroid space at that period of life. It cannot be recommended in cases of acute or extensive disease or injuries of the larynx; nor is it likely to be of much service if a foreign body is in the trachea or bronchus. On the other hand, it is generally applicable in the adult subject, especially in the male. And it is probably the best operation to adopt in cases in which foreign bodies are impacted in the larynx, in cases of limited chronic disease, or contractions about the upper part of the larynx, such as often result from syphilitic ulceration, etc.; and in cases in which respiration is impeded by polypoid or warty growths, and in which it is deemed right to open the windpipe before removing the growths.

2. *Laryngo-tracheotomy.*—In this operation the crico-thyroid membrane, the cricoid cartilage, the crico-tracheal membrane, and the first ring or two of the trachea, are divided. The general method of proceeding is similar to that practised in laryngotomy, but the first incisions must be somewhat longer; and in opening the windpipe the edge of the knife should be directed from below upwards, so as to avoid wounding the isthmus of the thyroid body. This structure is comparatively large and vascular in early childhood, and if wounded is liable to bleed freely.

Laryngo-tracheotomy may be advantageously practised if, on account of the age of the patient, the crico-thyroid space is too small to admit an opening of sufficient size, and if, at the same time, the surgeon fears to open the windpipe lower down. This operation should not be performed in the case of an adult, because of the damage necessarily done to the vocal apparatus. When the cricoid cartilage has lost its early elasticity, the divided edges must be forcibly kept asunder, or a portion of the cartilage must be cut out. Either proceeding is likely to result in more or less permanent impairment of the voice, or aphonia. Necrosis of the cartilage also is liable to occur. Two fatal cases of the kind have come under my observation.

3. *Tracheotomy.*—In this operation the opening is made into the trachea either above, through, or below the thyroid isthmus. The operation above the thyroid isthmus differs in no important respect in its method of performance from laryngo-tracheotomy, except that the opening in the windpipe is limited above by the cricoid cartilage, and it may be requisite to draw the thyroid body downwards. In childhood, this operation does not afford sufficient room for the introduction of the canula, and in the adult the operation below the isthmus is generally preferable. The operation through the thyroid isthmus cannot be recommended. It involves putting two ligatures round the isthmus, and dividing this structure between them. Before this can be satisfactorily accomplished, considerable venous and even arterial hemorrhage are likely to occur, and, until arrested, to cause much embarrassment.

The operation below the thyroid isthmus is that which is ordinarily understood by the general designation, tracheotomy. The advantages, as compared with the risks and difficulties, of opening the trachea in this situation, are greater than those afforded by making the opening higher up. As a

[1] Sir W. Fergusson mentions a case.

[2] See first edition of this work, vol. ii., p. 311.

[3] What is known to ladies as French braid is best.

general rule, therefore, this operation is to be preferred. The dangers and difficulties that may be encountered are unquestionably great, especially in the case of a young fat child; but they are not by any means so formidable as is sometimes supposed, and, for the most part, may be certainly avoided by care and skill on the part of the surgeon.

The operation may be performed either by a process of slow and careful dissection, or by a more rapid but probably equally safe method. The first method is practised as follows:

The patient, under chloroform or not, is put into the position already described. The facility with which the operation may be completed greatly depends upon the maintenance of this position throughout. The surgeon stands on the right of the patient. A careful preliminary examination of the parts is made, and the spot selected at which the trachea is to be opened. An incision is then made exactly in the middle line, extending from just above the cricoid cartilage nearly as low as the sternum. In the case of a short-necked fat patient it is very desirable to make the first incision long enough. The subcutaneous fat and connective tissue being divided, the sterno-hyoid muscles are brought into view, lying in close proximity one to the other, but between them a faint median line may generally be recognized. The fascia along this line is divided, and the muscles are hooked apart. The dissection is then cautiously continued through the fascia and connective tissue still in front of the trachea. These structures [can be separated generally by the free use of the handle of the knife or] are divided layer by layer, and held carefully aside, together with any veins that may be seen. The position of the trachea is from time to time sought with the finger, and the absence of any large abnormal vessel ascertained. The dissection is continued until the rings of the trachea are clearly visible, and at least as much of this tube is seen as it is intended to incise. During the progress of the dissection, all bleeding vessels are secured as far as possible; and if it happens that the necessary delay is of no importance, all hemorrhage is arrested before the trachea is opened. The point of the knife (the edge being directed upwards) is then thrust into the trachea, and carried upwards to such an extent as at once to make an opening of sufficient length. During this part of the operation the trachea is steadied and the knife is guided by the left forefinger of the operator. The tip of the finger is at once glided over the opening made, so as to serve as a guide in the subsequent introduction of the dilator or canula, and in the meantime to prevent the entrance of blood. This stage of the operation may be accomplished in a somewhat different and probably better manner, especially if the patient is young, and the trachea is small, and has but little resisting power. Instead of using the finger, the trachea is seized by means of a sharp single or double hook, and is drawn somewhat forwards and upwards, and firmly held while the opening is being made and until the dilator or canula is introduced. The last stage of the operation varies with the object in view. If the operation has been undertaken on account of the presence of a foreign body, the edges of the opening in the trachea are at once separated as widely as possible either by blunt hooks, by dressing-forceps, or by one of the dilating instruments especially made for the purpose, and the general plan described at p. 493 is pursued. If, however, the operation has been rendered necessary by laryngeal obstruction, the canula (already furnished with tapes for fixing) is introduced as speedily as possible.

Such is a brief description of the method of performing tracheotomy ordinarily recommended. But simple, easy, and safe as this method may seem in description, it is often complicated and difficult, and sometimes, from the delay involved, even dangerous in practice. Plenty of time, a good light, and, above all, skilful assistants, are absolutely necessary to enable the surgeon to accomplish his task with facility, if he adopt this method of operating. But it often happens that there is not a minute to be lost, and the surgeon must rely on himself alone. He may be called upon to operate at night, and there may be no good lamp at hand. Under such circumstances, it is impossible to make a deliberate dissection without endangering the life of the patient. Unskilful attempts to hook aside the divided structures embarrass rather than aid the operator. The natural laxity of the several layers of connective tissue of the neck is greatly increased by their division; and the various parts become capable of being moved so easily, and to such an extent, that they are almost sure to be pulled more or less out of position, and their normal relations disturbed. Thus the surgeon may be misled, and seriously hindered in the accomplishment of his purpose.

It has happened, to my knowledge, that the cervical vertebræ have been safely reached before the trachea has been found. The trachea on the one side and the large vessels on the other were held scrupulously apart by the assistants who had charge of the retractors.[1] Mr. Marsh[2] alludes to a similar case.

[1] See Durham on "Some of the Difficulties and Dangers of Tracheotomy," Practitioner, April, 1869, p. 226.

[2] Op. cit., p. 351.

In the absence, therefore, of skilled assistants and a good light, and especially if suffocation is impending, and every moment is of consequence, the following method should be adopted.

The surgeon standing on the right side of the patient, who is firmly held in the position already described, makes a rapid but careful preliminary examination of the parts. He then places the forefinger of his left hand on the left side of the trachea, and the thumb on the right, and makes uniform, steady, deep pressure, until he is able to feel the pulsation of both carotid arteries. By now very slightly approximating the finger and thumb, the surgeon feels that the trachea is firmly and securely held between them, and he has the satisfaction of knowing that the safety of the great vessels is insured. Moreover, the skin and superficial structures are rendered tense, and prevented from being moved downwards with the knife. The finger and thumb thus placed are not to be moved until the trachea is reached. In the next place, by a succession of careful incisions (not by a hasty plunge) the surgeon cuts confidently down on to the trachea. The finger and thumb accurately placed on either side, help him to judge the exact position of the median line, from which the knife must never deviate. And their pressure causes the wound to gape and the trachea to advance. The forefinger of the right hand is passed from time to time into the wound, "to make assurance doubly sure," that there is no important vessel in the way. When the trachea is reached (as may be known by the sensation communicated through the knife, or by examination with the right forefinger), it may either be opened at once, or it may be seized by a sharp hook, and opened as in the previously described method. If the trachea is opened without the use of the hook, the knife should be guarded, lancet-like, by the forefinger of the hand that holds it.

It will be observed that in operating in the method thus described, the trachea is firmly fixed throughout; and the violent convulsive up and down movements which commonly give rise to so much difficulty and embarrassment are effectually obviated. The pressure of the finger and thumb also prevents in great measure venous hemorrhage during the operation; and, as a rule, there is no need to pause and seek the wounded vessel. The whole operation, from the first incision to the opening of the trachea, occupies so short a time, that the interference with the respiration caused by the necessary pressure is of no moment. I have adopted this method in nineteen cases, and in no instance have I had the slightest reason to regret the course pursued. In several, life would have been sacrificed, or at any rate imperiled, if a slow dissection had been attempted.

Besides the methods thus described, others have been from time to time advocated by different surgical writers. But such methods do not appear to possess any peculiar advantages or merits entitling them to special description in these pages.

Various instruments called *tracheotomes* have been contrived with the view of rendering the operation more easy and less hazardous. But the use of all such instruments is condemned by practical experience; and that too, in spite of the undeniable ingenuity displayed in the construction of some of them. The surgeon who is competent to operate does not require anything of the kind; and in the hands of the incompetent such contrivances are likely to prove dangerous.

Whichever method of operating be adopted, the following general observations may be equally applicable.

1. With regard to *hemorrhage*. Fatal hemorrhage during the operation very rarely occurs, and need not be feared if only due care and promptitude are exercised. There can be no doubt that in some, if not many, of the so-called cases of fatal hemorrhage, death has really resulted not from loss of blood, but from want of breath; and that, because the surgeon has been deterred by fear from completing his operation.

Nothing but gross carelessness, or utter loss of presence of mind on the part of the surgeon, or uncontrolled struggling on the part of the patient, can explain the opening of the innominate or carotid artery. Such an accident, however, has occurred. It certainly ought to be remembered that the innominate may cross the trachea higher than in the normal arrangement. But an artery of such size must be detected if proper examination of the parts is made. Nor ought there to be any difficulty in discovering and dealing with the abnormal artery "as large as the radial," which is described as having been sometimes met with in front of the trachea. The thyroidea ima, not unfrequently found in this situation, is rarely of sufficient size to give rise to serious hemorrhage, if only its possible presence is borne in mind, and search is made for it in cases of arterial bleeding after the canula is inserted.

But although fatal hemorrhage is very rare, yet bleeding to a very considerable and even alarming extent often occurs, especially in cases of sudden or rapid obstruction to respiration. Such bleeding is almost always venous, and usually comes from some communicating branch or other of the anterior jugular or inferior thyroid veins. It is sometimes impossible to avoid these veins; but every endeavor should be

made to do so by keeping strictly in the middle line [and by tearing the tissues rather than using the knife]. Any vessels that may be wounded should be at once secured by ligature or pressure, if practicable; but attempts to do this should not be persevered in to the risk of the patient. The rule has been laid down, and repeatedly quoted, that the trachea should never be opened until all hemorrhage has ceased. If the surgeon invariably abides by this rule, he will assuredly sometimes have to wait until his patient is dead. It is useless to let the patient die from suffocation, while attempting to prevent death from loss of blood; and yet this has been done. In any case in which there is great venous congestion, and the patient is on the point of suffocation, the surgeon must go boldly but carefully on, and complete his operation as quickly as possible, in spite of what may seem almost frightful hemorrhage. He must not hesitate in such a case to open the trachea, and introduce the canula even through a very pool of blood. When the canula is in position, and respiration is restored, either by natural recovery or by artificial aid, the blood moves on through the before congested pulmonary capillaries; the right side of the heart is relieved from distension; the blood flows on in its natural course; the previously distended veins resume their normal dimensions; and the profuse hemorrhage speedily subsides, or is easily arrested by pressure.

2. With regard to *the opening in the trachea.* In making the opening into the trachea, it is important to keep strictly in the middle line; otherwise, as pointed out by Mr. Paget, "the canula is likely to stand awry in the wound, and its extremity will be turned sharply against the mucous membrane of the trachea, and will not only cause irritation [ulceration and hemorrhage], but will quickly become blocked with mucus."[1] It is also important not to thrust the knife too far into the trachea. Mr. Marsh mentions an instance in which "the scalpel was driven through both the anterior and the posterior walls of the trachea, and through the œsophagus till it struck the spine." But although the knife must not be thrust too far, it is almost more important to take care that it is thrust far enough, and that it is made to incise the trachea to a sufficient extent. It must be borne in mind that the mucous membrane of the trachea, especially if inflamed and swollen, may be pushed before the knife instead of being penetrated; and also that false membranes lining the tube may similarly be pushed before the knife, and on its withdrawal may, valve-like, close the opening. If the opening first made into the trachea is too small, and escapes detection when sought, it is better to make a second opening at once, rather than to lose much time in searching for the first. Experience shows that comparatively little danger, or none at all, is likely to arise from such a proceeding.[1] If the opening made in the trachea should be larger than it need be, and the wound through the skin too small or too completely closed, air may escape by the side of the canula into the areolar tissue, and emphysema may result. This accident, however, is rarely met with, and is not, as a rule, of any importance. Absorption soon takes place.

3. With regard to *the introduction of the canula.* This is often found to be a matter of some difficulty; and cases have occurred in which the canula has been thrust, and allowed to remain until death, in the areolar tissue surrounding the trachea.[2] In such cases, the pressure of the canula has further impeded the already obstructed respiration.[3]

To facilitate the introduction of the canula, Trousseau,[4] and, following him, most French surgeons, recommend the use of dilating forceps. Trousseau's bivalve dilating forceps may be used for this purpose, or the trivalve forceps of Laborde (see FIG. 152, p. 494). In England, the bivalve canula of Dr. Fuller (see FIG. 155, p. 900) is somewhat in favor, on account of the comparative ease with which it may be inserted. Practically, however, it will be found by far the best plan to use the ordinary cylindrical canula mounted upon a blunt pilot trocar (see FIGS. 154 *c*, 158, pp. 900, 902). By this means, the introduction of this canula is rendered easier than that of the bivalve canula, to the use of which there are many objections; and the operation is simpler than when a dilator is employed. If the surgeon should not possess a trocar, an elastic catheter or bougie may be used as a substitute. But the long firm handle of the trocar renders the manipulation of the instrument so mounted much more easy.

4. With regard to *the completion of the operation.* In every case, however apparently hopeless it may have become, the surgeon should complete his operation. The tube should be introduced even though the patient have ceased to breathe before this can be accomplished; and the most persevering efforts should be made to effect resuscitation by aid of artificial respiration. Blood that may have entered the trachea must be sucked out by the mouth of the

[1] Marsh, op. cit., p. 351.

[1] A good illustration is mentioned by Holmes, op. cit., p. 323, note.

[2] Marsh, op. cit., p. 352.

[3] Holmes, p. 323.

[4] See Trousseau, Clinique Médicale, 1868, t. i., p. 466.

surgeon, or by means of a syringe (if the disease is of infectious nature); its entrance may be prevented, and its expulsion favored by turning the patient on his face from time to time. Under such treatment recovery has been repeatedly effected in cases apparently the most hopeless.

The canula.—Attention to the size, shape, and general construction of the canula is of great importance. It should always be double; that is to say, it should consist of an outer tube which remains fixed in the trachea, and an inner tube which may be removed from time to time. Sometimes the canula is too short, and the neck-plate becomes buried in the wound. Sometimes it is too long, and presses

Fig. 148.

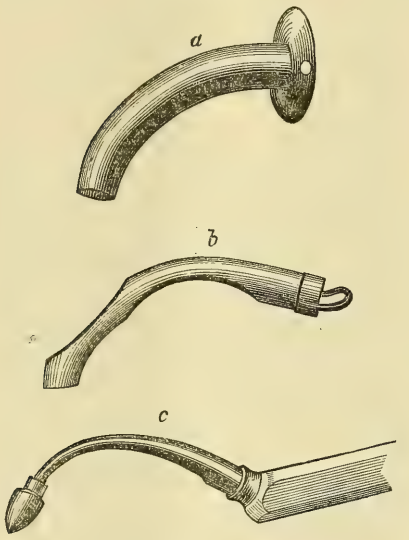


FIG. 148. Ordinary Tracheotomy Canula. *a*. Outer tube. *b*. Inner tube. *c*. Blunt-pointed pilot trocar.

against the œsophagus behind, and projects in front to a greater or less extent from the wound, in which case it is very liable to be forced out. The canulas in ordinary use are so curved that the lower extremity often impinges on the mucous membrane of the anterior wall of the trachea; and sometimes the convexity of the curve comes in contact with the posterior wall. In either case ulceration may be produced sooner or later, and very serious results may follow. "Two cases have occurred in Guy's Hospital, in each of which ulceration so produced extended through the anterior wall of the trachea into the innominate artery. Fatal hemorrhage of course ensued."[1] Another instance of the same kind is recorded by Mr. Wood.[2] And even in cases in which there has been no reason for supposing that any large trunk has been perforated, serious and occasionally fatal hemorrhage has occurred. Mr. Marsh[1] states that four or five cases have come under his observation. Again, abscesses, bronchitis, pneumonia, pyæmia, and other more or less fatal conditions, have sometimes resulted directly or indirectly from the inflammation or ulceration set up by the canula. It is easy to understand that in all cases the presence of the canula is likely to set up more or less local irritation and inflammation, which may spread along the air-tube. But that such serious results should ensue as those described, seems to indicate something wrong in the construction or management of the canula.

The canulas ordinarily met with in this country are of three kinds. First, the ordinary English canula, which consists of an outer tube complete throughout (FIG. 148 *a*), and an inner tube cut away on its convex and concave aspects (FIG. 148 *b*), so as to facilitate its passage into and out of the outer tube. The curve of this canula represents about a quarter of a circle. Second, the ordinary French canula, somewhat less curved. Both the inner and outer tubes are complete. Thirdly, the bivalve canula of Dr. Fuller, in which the

Fig. 149.

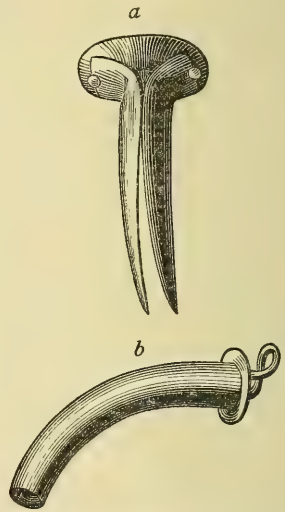


FIG. 149. Dr. Fuller's Bivalve Tracheotomy Canula, *a*. Outer portion viewed from behind. *b*. Inner tube, side view.

[1] Durham, in Practitioner, p. 220.
[2] Path. Trans., vol. xi., p. 20.

[1] Op. cit., p. 364. On the dangers due to the presence of the canula, see also Trousseau, op. cit., p. 477; H. Roger, in Archives Générales; Med. Times and Gaz., vol. xix., Report on "Tracheotomy."

outer tube is represented by two blades (Fig. 149 *a*), which may be approximated by the finger and thumb during the introduction of the instrument, and are afterwards kept apart by the insertion of a complete inner tube (Fig. 149 *b*), through which respiration is carried on.

In each of these forms, the canula is rigid throughout, and therefore is liable to press continuously upon any spot upon which it may impinge.

The improved French canula of M. Roger is so constructed[1] that though the neck-plate is fixed, the tube in the trachea is allowed to move to a certain extent with the motions of the parts. Trousseau[2] states that since such canulas have been in use at the Hôpital des Enfants Malades, ulcerations of the trachea have been much less frequently produced.

Canulas of the various forms described are made of different sizes. It has been repeatedly asserted that the canula should be as nearly as possible of the same calibre as the trachea into which it is to be inserted. But this is altogether a mistake, and any attempt to carry such an idea into practice cannot fail to be dangerous.

Mr. Marsh[3] has shown by a series of careful measurements that the calibre of the cricoid cartilage is considerably less than that of the trachea. Mr. Holmes[4] has further shown, in a similar manner, that the area of the glottis when fully expanded is smaller than that of the transverse section of the cricoid. Moreover, it may be readily seen, on laryngoscopic examination, that during ordinary tranquil respiration the glottis never is expanded to its fullest extent. Thus it becomes evident that there is no need to employ a canula the calibre of which is anything like equal to that of the trachea. And a little consideration shows that it would certainly be unphysiological and probably dangerous to make the attempt. It may safely be accepted that the ordinary canulas are of sufficiently large calibre for the purpose intended.

With regard to their length and curvature, however, there is room for improvement, as is clearly indicated by what has been already advanced. With the view to obviate the possible sources of danger to which the canula may give rise, and some of the difficulties connected with its management, I recently devised the form of canula represented in Figs. 150, 151, 152.[5] The outer tube (Fig. 150) is so shaped as to pass straight back into the trachea, and then to turn downwards in such a manner that its extremity may lie in the middle of the trachea, and its edges may not press against the mucous membrane. The straight portion A slides in the collar B, but can be fixed at any point by means of the screw C. The length of the portion of the tube in the wound is thus easily regulated in accordance with the depth at which the trachea is situated. The projection of the end of the tube beyond the collar prevents mucus, etc., when once expelled, from being drawn in again by the next inspiration. The collar B is attached to the small plate D, which is loosely articulated with the neck-plate E by means of two alar processes, which pass under little wire arches on E in such manner as to permit the portion of the tube in the trachea to accommodate itself in position during the various movements of the head and neck. The distal portion of the inner tube (Fig. 151) consists of several small pieces jointed together in the "lobster-tail" fashion. The adoption of this construction enables this tube to pass easily into and out of the outer tube. The pilot trocar (Fig. 152) is constructed on the same principle. Experience has now amply shown that the advantages presented by this form of canula are not simply imaginary.

Fig. 150.

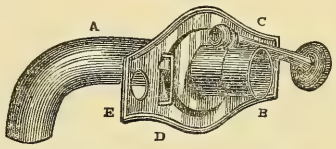


Fig. 150. Durham's canula, outer tube.

Fig. 151.

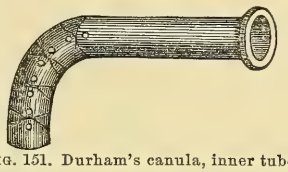


Fig. 151. Durham's canula, inner tube.

After-treatment, complications, and accidents.—After the operation is completed, and the paroxysmal fits of dyspnœa and violent cough which immediately follow the insertion of the canula have subsided, the patient usually experiences the greatest possible relief, and is soon ready to sink into a peaceful sleep. The edges of the wound should be approximated by means of a strip or two of sticking plaster, or may be left altogether open. Sutures, as a rule, should not be used. The surrounding parts of the neck should be well oiled over if the patient is suffering from diphtheria. And in such case it may be a good plan to apply

[1] The construction by which this is effected is adopted in the canula, Fig. 156.
[2] Op. cit., vol. i., p. 477.
[3] Op. cit., p. 342.
[4] Op. cit., p. 325.
[5] Made by Mayer and Meltzer.

nitrate of silver to the cut surfaces in the manner recommended by Trousseau. As a general rule, the simplest after-treatment only is requisite. But such simple treatment, to be effectual, requires the greatest vigilance, and sometimes considerable skill.

Fig. 152.

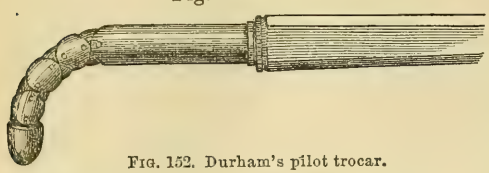


Fig. 152. Durham's pilot trocar.

The patient should be surrounded by a warm and moist, but not oppressively close, atmosphere. The general temperature of the room should be uniformly maintained; and dishes of hot water, or some specially contrived apparatus, should be so arranged as to moisten the air the patient is about to breathe. Water kept boiling in a Florence flask by means of a spirit-lamp may be made to answer the purpose; or a long tube may be attached to the spout of a kettle on the fire, and the steam which issues from it directed towards the patient's neck. It might be well if he could breathe the "atmosphere of an orchid house"[1] without being in it. If the patient should unfortunately be placed in the midst of a large hospital ward, his bed must be partially surrounded by a tent-like arrangement of screens and blankets.

In most cases in which tracheotomy has been performed, especially in those in which it has been rendered necessary by croup, diphtheria, acute laryngitis, etc., the constant attendance of a vigilant and skilful nurse during a longer or shorter period is absolutely required. The superlative importance of careful watching, judicious management, and unwavering perseverance to the very end, cannot be exaggerated. For want of such watching, management, and perseverance in the after-treatment, many patients have been lost. In such cases, the operation has usually been followed by immediate and intense relief, and it has been too readily supposed that nothing more need be done.

The special treatment required varies with the accident or disease which has rendered the operation necessary. If, for example, it has been performed on account of the presence of a foreign body, as soon as the foreign body is removed or expelled the canula may be removed, and the wound allowed to cicatrize. If it has been performed on account of croup or diphtheria, constitutional treatment may be necessary. If it has been performed on account of obstruction arising from the effects of syphilitic disease, constitutional as well as local treatment is called for. In all cases, however, it is requisite that blood, mucus, discharges, and membranes should be wiped away immediately on their expulsion from the canula, and that the inner tube should be withdrawn, cleaned and replaced as often as may be needful. The dry tenacious stuff that so rapidly and firmly blocks the canula, and is sometimes so difficult to clean off, may be readily softened by immersing the tube in a weak solution of potash. Before reintroducing the inner tube, it should always be thoroughly oiled. When the period is reached at which the tube no longer requires constant watching and changing, it is a good plan to place over the neck of the patient a small light cradle on which two or three layers of moistened muslin are lightly laid. The air is thus moistened, and the entrance of dust, etc., is prevented.

The after dangers of the case arise in great measure from the progress or effects of the disease or accident which may have rendered the operation necessary.[1] But there can be no doubt that the operation itself, and especially the retention of the canula, may expose the patient to certain risks. Bronchitis and broncho-pneumonia not unfrequently result, and sometimes prove fatal. These affections may be caused, directly, by the admission of unwarmed, unmoistened air to the lungs; or indirectly by the extension of inflammation from a spot irritated or ulcerated by the pressure of the canula.

In all cases it is desirable to dispense with the use of the canula at the earliest possible period, not only to relieve the patient from the risk occasioned by its presence, but also to favor the restoration of the vocal apparatus to its normal state. The canula should be closed for a time by the finger or other means, and the attempt should be made to ascertain how far respiration can be naturally accomplished. The experiment should be persisted in at intervals, until it becomes evident either that the canula may be safely withdrawn, or that it would be hazardous to do so. The canula should not be withdrawn unless the patient can be watched by an attendant competent to replace it in case of need. Before withdrawing the canula, it should have been ascertained that the patient can breathe for some hours with the orifice plugged. Small silver plugs, with perforations of different sizes, may be advantageously used.

[1] Cooper Forster, Surgical Diseases of Children, p. 54.

[1] See the article in the Practitioner already quoted.

In some cases the muscles of the larynx waste, and become inactive from prolonged disuse. In other cases obstacles to the restoration of natural respiration arise from the presence of exuberant granulations which spring up around the tracheal opening.[1] In other cases, again, contractions of the diseased or injured part occur. In each class of cases an attempt should be made to remove the source of the difficulty: in the first class, by inducing exercise; in the second, by appropriate applications; in the third, by dilatation.

After the canula has been removed, the opening made, as a rule, speedily closes. It very rarely happens that any serious constriction of the trachea results; unless, indeed, a considerable portion has been injudiciously removed in the course of the operation.

In many cases the canula cannot be safely dispensed with until after the lapse of months or years; and it may be necessary during the remainder of life. In such cases it is very important to remove and examine the canula from time to time, for it is liable to undergo a process of slow corrosion. Mr. South mentions an instance in which the tubular portion became detached from the neck-plate and dropped into the trachea. Mr. Hilton has met with two similar examples. In each case the detached portion was successfully removed from the trachea by means of forceps, but not until after life had been seriously imperiled. If it should be necessary to wear the canula during a prolonged period, it is better to exchange the silver canula first employed for one made of vulcanite. Such canulas are much lighter, more comfortable to wear, and being less sharp, are not so likely to cause ulceration of the mucous membrane.

The diseases and accidents which render it necessary to make an opening into the windpipe are very various. The period at which the operation should be performed, and the spot at which the opening should be made, vary with the particular conditions which may demand the operation. These points are discussed in the several sections which refer to such conditions. In general terms it may be stated that one or other of the operations described may be necessary in any case of disease or injury which produces pathological or mechanical impediment to the free passage of air towards the lungs; and that in any such case the surgeon must be prepared to operate at any moment.

Foreign Bodies in the Pharynx.

Foreign bodies of various kinds often become fixed in some part or other of the pharynx. If thin and pointed, such as pins, needles, fish-bones, bristles, etc., they most frequently stick between one or other of the pillars of the fauces and the tonsil, or in the mucous folds connecting the base of the tongue with the epiglottis. If more bulky, such as portions of food, pieces of money, etc., they generally become arrested at or about the junction of the pharynx with the œsophagus, where the tube is narrowest and least easily expansible (the cricoid cartilage being in front), and where the muscular coat changes its character.

However small the foreign substance may be, it occasions much discomfort until it is removed; and the sense of discomfort often remains some time after removal has been effected. A small pointed body sticking between the pillars of the fauces, or between one of them and the tonsil, causes more or less local pain, with a pricking sensation, increased on pressure behind the angle of the jaw. Sometimes there is considerable difficulty in swallowing, and pain on attempting to do so, accompanied by a disposition to vomit. Occasionally spasmodic contraction of the pharynx and œsophagus is excited. If the foreign body sticks in the mucous membrane at the root of the tongue, near the upper orifice of the larynx, in addition to the symptoms already mentioned, cough and more or less difficulty of breathing sooner or later come on.

An interesting case related by Mr. South[1] shows the severity of the symptoms that may be produced by a foreign substance in this situation, and also the care needful for its detection. A lady swallowing a morsel of food felt a sharp substance stick in her throat. She experienced constant pricking pain, and in the course of a few hours began to suffer from cough and repeated attempts at deglutition. Nothing being found on examination, the case was considered to be one of local irritation. In the course of twenty-four hours the symptoms became so aggravated as to threaten suffocation. She was seen by Mr. Tunaley, and tracheotomy was at once performed. On subsequent examination with the finger, the point of what was supposed to be a pin was felt when an attempt was made to swallow. The foreign body was removed by means of a pair of dressing forceps bent for the purpose, and proved to be a bristle about an inch in length. This was believed to have penetrated the mucous membrane at the root of the epiglottis, and to have produced spasm of the glottis by the irritation set up.

Sometimes a small sharp body may penetrate the pharyngeal wall, and give rise to serious or fatal hemorrhage by wounding the carotid or some other important artery.

Mr. Joseph Bell[2] records the case of a lad

[1] On such conditions see the excellent paper of Mr. T. Smith, Med.-Chir. Trans., vol. xlviii., p. 227.

[1] South's Chelius, vol. ii., p. 384.

[2] Medical Gazette, 1842-3, p. 694.

who "swallowed" a sewing needle with his food. He felt some pain, but the accident was not considered to be serious, until the ninth day, when he began to spit up blood. On the tenth day there was great hæmatemesis, and death took place in a few minutes. On examination, the larynx and trachea were found to be filled with clotted blood. So also was the stomach. The pharynx was transfixed opposite the middle of the thyroid cartilage by a sewing needle three inches long, the point of which had penetrated the common carotid artery.

Occasionally foreign bodies get into the pharynx from without by passing through the skin and other superficial structures.

Mr. Jardine Murray[1] relates a remarkable case in which he removed from the pharynx of a woman a sewing needle which had stuck into her neck half an hour previously.

Foreign bodies when large, as already stated, usually become impacted at the part where the pharynx becomes continuous with the œsophagus. Occasionally, however, they may be arrested higher up. A striking example is afforded by a case narrated by Mr. Paget.[2]

An old gentleman lying down faint, or in a slight epileptic seizure, got one of his sets of false teeth into his pharynx. He became half conscious, and for a time suffered from dyspnœa and a sense of choking. These symptoms subsided in a few days. He had, however, some difficulty in swallowing, which gradually increased. He had frequent short hacking cough. He felt constriction about his cricoid cartilage, but no considerable pain. The symptoms were not explained, for no examination was permitted. Four months after the accident he was seen by Mr. Paget, who, on depressing the tongue, indistinctly saw something white near the epiglottis, and on introducing his finger at once felt and easily hooked up the missing set of teeth. This consisted of a large palate plate with nine false teeth attached, and having spaces to fit round three remaining natural teeth. "The piece lay between the base of the tongue and the epiglottis, very closely fitted to all the surface on which it rested." It is certainly worthy of note that so large a foreign body should have remained in the pharynx without seriously obstructing respiration or absolutely preventing swallowing.

As a general rule, foreign bodies of large size, impacted in the lower part of the pharynx, speedily cause death from suffocation, either by compressing the upper part of the larynx or by producing spasm of the glottis. In some cases death occurs so suddenly that the patient is supposed to have died of apoplexy. Numerous instances are on record. Such an accident is most likely to happen if the the pharyngeal muscles are partially paralyzed.

Two cases of this kind have occurred within the last few years in Guy's Hospital. In each case the patient was under treatment for paralysis. In each death took place suddenly, during a meal; and on examination a portion of food was found in the pharynx pressing upon and completely closing the entrance to the larynx. Mr. South narrates the following curious example of arrest of a foreign body in the pharynx. A medical man, eating his breakfast in haste, suddenly felt choked. He could not swallow the morsel in his throat, and he could not breathe. He thrust his fingers back, and tried to pull out the portion of food. He succeeded in his attempt, and found that the piece of meat half-swallowed was attached by a thread of fibrous tissue to another piece which had became entangled in his teeth. This thread had pressed down the epiglottis, so that every effort to swallow only made him worse. A similar accident occurred to the same gentleman on a second occasion, and relief was similarly obtained.

Hard irregular substances, with sharp points or angles, as fragments of bone, impacted in the upper and back part of the pharynx, may cause ulceration, and lead to various serious complications. In some instances, caries of one or other of the upper cervical vertebræ has resulted.[1]

Mr. C. H. Moore[2] relates two cases in which deepseated abscesses in the neck followed the impaction of foreign bodies in the pharynx. In each of these the foreign body was extracted externally after the abscess had been opened. In one case the foreign body was a piece of straw; in the other (under the care of Mr. Hulke) a husk of grass.

Treatment.—In every case, the most careful attempts should be made to discover, and to remove through the mouth, any foreign body that may have become impacted in the pharynx. Should such attempts prove successful, the patient is not only relieved from immediate pain and discomfort, but is spared from the risk he might have to encounter if the foreign body were pushed, or allowed to pass, further down the gullet.

The foreign body, if small and sharp, should be carefully sought by sight and touch; and when discovered, removed by the finger, or with appropriate forceps. More harm than good is likely to result from indiscriminately and roughly wiping round the fauces with a sponge, on the chance of catching the foreign body.

The widely-opened mouth of the patient may be illuminated either by placing him

[1] Medical Times and Gazette, May 7, 1859, p. 468. In this paper reference is made to numerous interesting cases both in man and the lower animals.

[2] Medical Times and Gazette, Jan. 18, 1862, p. 58.

[1] See cases by Fleury and Schupfe, quoted in Nouveau Dictionnaire de Médecine et Chirurgie, art. Atloïdienne, p. 797.

[2] Lancet, Sept. 10, 1864, p. 287.

opposite a good light, or by aid of the frontal mirror of the laryngoscope.[1] When the patient is made to inspire deeply, and the tongue is depressed, the soft palate becomes raised, and the pillars of the fauces are widely separated. Under such circumstances, a small, sharp extraneous substance sticking in the folds of the palate, or between them and the tonsil, may often be seen. Sometimes the laryngeal mirror, properly directed, may be used with very great advantage.

If the foreign substance cannot be seen, the finger may be introduced into the pharynx, and gently passed over the surface of the mucous membrane. Care should especially be taken to explore thoroughly the sulci between the pillars of the fauces and the tonsil. If the foreign body should be low down in the pharynx and beyond the reach of the finger, it may sometimes be detected by means of the laryngeal mirror, or by examination with a long probe, or slender properly curved forceps. If after thorough search the foreign body remains undiscovered, it is sometimes better to wait until the next day, rather than to proceed to the indiscriminate wiping round of the pharynx so often practiced, and to which allusion has been already made. A bristle or a herring-bone, or any such substance, often becomes extricated after a time, and passes on down the gullet.

If a large foreign body seriously interferes with respiration, and is too firmly impacted to be at once removed, laryngotomy must be performed without delay. Further attempts at removal may then be made in safety; or if these fail, the foreign body may sometimes be pushed on into the stomach.

Habicot[2] relates a very successful case of this kind. A lad, fearing to be robbed, attempted to swallow nine pistoles wrapped up in a piece of linen. The packet could not pass the narrow part of the pharynx, and suffocation impended from its pressure. The windpipe was opened, and the boy's life was saved. The pieces of gold were subsequently pushed on into the stomach, and were discharged from the anus eight or ten days afterwards.

Coins, arrested in the lower part of the pharynx, obstruct the passage of the food and impede respiration in a degree varying, not only with their size and precise position, but also with the direction in which they lie.

I have, in two cases, extracted a halfpenny from this part of the pharynx, or the upper part of the œsophagus of a child. In one case the child had been absolutely unable to swallow even fluids since the accident, a period of six days, but respiration was scarcely affected. The child was almost starved to death. In the other case, the child had been able to swallow fluids tolerably well, but the breathing was somewhat impeded and croupy, and the voice was lost. A few hours only had elapsed since the accident, but there was considerable and increasing distress. In the former case the coin was lying with its flat surfaces upwards and downwards, and on the upper surface was a little heap of condensed alimentary materials. In the other case the coin was fixed obliquely across the food passage, and its edges were upwards and downwards. In each case the coin was extracted without difficulty by means of the "money-probang" figured on page 908. In the case in which the coin was lying flat, some force was required to push the probang past it.

If the foreign body is very irregular, or covered with sharp projecting points, as an artificial tooth plate, and is too low down to be reached, or too firmly fixed to be removed without dangerous violence, the operation of pharyngotomy may be performed. This operation, which practically need not be distinguished from that ordinarily termed œsophagotomy, is discussed under this latter title on p. 909 et seq.

A foreign body may remain in the pharynx for a considerable period.

Dr. Ogier Ward[1] records a case in which a halfpenny was impacted in the pharynx of a child during eight months. Stridulous breathing and difficulty in swallowing came on immediately after the accident. The child could only suck one mouthful of milk at a time, and was obliged to withdraw from the breast at each attempt to swallow. One morning, after a severe fit of coughing the day before, the child took the halfpenny out of his mouth and gave it to his father. The halfpenny was much worn and corroded, and was thickly coated with dried mucus and masticated food. The patient gradually recovered.

Monro mentions a case in which an extraneous substance, arrested at the termination of the pharynx, became lodged in a sac of some length which descended behind the œsophagus.

Rokitansky[2] remarks that "sometimes small hard bodies, such as cherry-stones, give rise to serious occurrences, by causing at different parts of the œsophagus, but chiefly at the lower constrictor of the pharynx, the formation of diverticula."

It may reasonably be questioned, however, whether in such cases it would not be more correct to suppose that the small hard bodies got into, and perhaps increased, diverticula already existing, than to state that the diverticula were originated by the presence of the foreign bodies.

Foreign Bodies in the Œsophagus.

A foreign body may become arrested

[1] See the chapter on the Laryngoscope, in vol. iii.

[2] Mém. de l'Acad. de Chirur., t. xii., p. 243.

[1] Pathological Transactions, 1848–49.

[2] Pathological Anatomy (Sydenham Society's Translation), vol. ii., p. 12.

and fixed in any part of the œsophagus. Generally, however, lodgment takes places either opposite the cricoid cartilage, or just above the diaphragm: it is in these situations that the tube is most constricted, and that the foreign body is most readily held by muscular spasm.

The substances that have been retained in the œsophagus are very various. Among the most frequent are portions of food, such as pieces of crust, or imperfectly chewed meat, fragments of bone swallowed in soup, pieces of money, pins, needles, buttons, artificial teeth, etc.; less frequently, knives, forks, scissors, spoons, keys, etc. In one instance the handle of a punch-ladle was rammed down the throat, and became impacted in the œsophagus.[1] In another instance a boy got a large pike-hook fixed in his own gullet.[2] Legouest[3] states, that small leeches are often swallowed, in drinking-water, by soldiers in campaign. They are apt to attach themselves to the walls of the pharynx or upper part of the œsophagus, and to give rise to considerable discomfort, frequent desire to vomit, and intermittent flow of blood from the mouth.

The symptoms and ultimate effects vary with the size, shape, and angularity or pointedness of the substance, and the position in which it becomes fixed.

If the foreign substance is small, it may simply produce irritation, with more or less dysphagia and pain in swallowing. Its long-continued presence, however, may excite inflammation, which may gradually go on to suppuration and ulceration.

If the foreign body is small in bulk, but pointed and sharp, as a needle, pin, etc., it may stick for a long time in the mucous membrane, and defy all attempts at removal. In other instances it may quickly become loosened by ulceration, and may be got rid of either by being vomited, or by descending into the stomach, and being voided with the fæces. Sometimes a foreign body of this kind penetrates the walls of the œsophagus, and subsequently pierces the trachea or the aorta, or finds its way on to some remote part of the body, and approaches the surface, and finally, after the lapse of months or years, becomes discharged through an abscess to which it has given rise. Sometimes fatal results speedily ensue.

A remarkable case is recorded by Mr. Andrew[4] as having come under his observation. A woman found on a doorstep in a dying state, was removed to University College Hospital. Before her admission she had ceased to breathe. On examination, a fish-bone was discovered perforating the stomach close to the œsophagus, "then the diaphragm and pericardium, and lastly the substance of the posterior surface of the heart; then inflicting a jagged wound in the middle of its septum, immediately over the right coronary artery and vein, and puncturing the latter vessel." . . . . "The pericardium was filled with a pint and a half of fluid blood, . . . poured out by the wounded vein." It is very probable, according to the report, that the bone was first impacted in the lower part of the œsophagus, then reversed in direction by the passage of a portion of food, and lastly by muscular contraction forced through the walls of the tube.[1]

If a comparatively large, hard, and angular or pointed foreign body is retained in the œsophagus, deglutition is, as a rule, rendered more or less difficult or impossible; and other results of the most serious character may speedily follow.

Dr. J. W. Ogle[2] records a case in which a portion of bone, arrested in the œsophagus, set up ulceration of an intervertebral substance. Disease of the spinal cord followed. Mr. Duncan of Edinburgh[3] relates a case in which the metal setting of some false teeth stuck in the œsophagus. The sharp points caused ulceration, which extended through into the arch of the aorta. Fatal hemorrhage ensued. Dr. Frederick Spry,[4] of the 2d Life Guards, brought before the Pathological Society, in April, 1868, a specimen illustrating the following interesting case. A trooper in robust general health, complained on March 24, 1868, "of indigestion and oppression at his chest, the result, he said, of having . . . . on the previous Saturday, swallowed a piece of gristle, which seemed to stick half-way down." Purgatives and emetics were administered, but without beneficial effect. Two days afterwards the patient seemed "very ill. His countenance was pale and anxious, and he suffered very much from pain in the chest." The pain increased and seemed to spread. In the afternoon he was able to swallow some milk. In the evening, after stooping, he suddenly vomited an enormous quantity of arterial blood, and fell back on his pillow, dead. On post-mortem examination, there was found about the middle of the œsophagus "a round blackish, ulcerated mass, the size of a threepenny piece," in the centre of which a sharp spicula of bone projected. The bone was traced on into "the aorta, in the ascending portion of which, about an inch and a quarter below the origin of the arteria innominata, a similar dark-colored patch of ulceration was detected, inclosing the other end of the bone. Across the ulcer a rent had taken place, about one-fifth of an inch in length." Mr. Bradley records the case of a "smasher" who attempted to swallow a counterfeit half-crown. Eight

[1] Museum of Royal College of Surgeons. Path. Catalogue, vol. iii., p. 28.
[2] Dr. Gillespie, Edin. Med., Journ., 1858, p. 770.
[3] Chirurgie d'Armée, p. 435.
[4] Lancet, Aug. 25, 1860, p. 186.

[1] See Edin. Med. Jour., vol. vi., p. 471.
[2] Pathological Transactions, vol. iv., p. 27. The specimen is in the Museum of St. George's Hospital.
[3] Northern Journal of Medicine, May, 1844.
[4] Pathological Transactions, vol. xix., p. 219.

months afterwards, death occurred from sudden profuse hemorrhage. The coin was found to have produced ulceration of the gullet extending into the aorta.[1]

Foreign bodies of large size impacted in the upper part of the œsophagus, may endanger life by pressing upon the trachea, and obstructing respiration.

Notwithstanding the risks involved, it has happened in some instances that foreign bodies have been retained a considerable time in the œsophagus without producing any mischief.

In the case to which allusion has already been made, an insane gentleman rammed the whalebone handle of a punch-ladle down his throat, with suicidal intent.[2] The instrument was extracted after having been in the throat sixty-two hours, during which period the patient had eaten, drunk, and slept as usual. No ill result followed, and the next day the patient was free from complaint. Monro mentions a case in which a halfpenny was retained in the œsophagus of a boy during a period of three years. After death from consumption, the halfpenny was found closely embraced by the gullet. Another case is also mentioned by Monro in which a halfpenny was removed by means of a blunt hook, after having been impacted in the œsophagus for six months.

Diagnosis.—It is not always easy to diagnose with certainty the presence of a foreign body in the œsophagus. The history of the case and the sensations described by the patient may sometimes be delusive.

If the foreign body is large and is impacted in the upper part of the tube, it may sometimes be felt on external examination, or it may be at once detected on attempting to pass a bougie or sound. Cases, however, have occurred in which foreign substances of comparatively small size, although retained, have not been discovered, even after repeated and careful examinations. On the other hand, there may be much local pain, considerable difficulty in swallowing, and even interference with respiration, although no foreign body is actually present. Such symptoms may arise from abrasion of the mucous membrane, and subsequent inflammation produced by swallowing a large irregular substance.

In the case of a sharp-pointed body of small bulk the diagnosis may be very difficult. At a meeting of the Medico-Chirurgical Society of Edinburgh (Jan., 1859), Dr. W. T. Gairdner narrated the history of a woman who was supposed to be suffering from typhus, and was accordingly sent to the fever ward of the hospital. The symptoms in the main were those of double pneumonia, accompanied by a peculiar laryngeal cough. Death occurred forty-eight hours after admission. On examination, a fish-bone, which had passed through the posterior wall of the œsophagus, was found imbedded in pus in front of the vertebral column. There was pus in both pleuræ, in the lungs, and in the pericardium.

Treatment.—Any foreign body impacted in the œsophagus should be removed as soon as practicable. The method to be adopted depends to a certain extent upon the size and character of the foreign substance, as well as upon the position in which it is fixed.

If the extraneous substance is known to be of moderate size, and of such nature that it may be easily digested, or of such shape that it is not likely to be hurtful in its passage through the stomach and intestinal canal, it may be gently pushed on into the stomach by means of a long flexible probang to the end of which a piece of sponge or an ivory knob is firmly attached (Fig. 161, *a*). If such a substance, however, should be lodged in the upper part of the canal, attempts should first be made to remove it by the finger, or by means of long curved forceps. The risk of injuring the mucous membrane of the œsophagus by the passage of the probang is thus avoided. Sometimes when the substance is in this situation it may be displaced, and subsequently removed, by digital pressure along the side of the neck.

Small, hard, pointed substances, such as pins, needles, nails, fish-bones, etc., should always be removed if possible, rather than pushed on into the stomach. In some such cases a probang to which a piece of dry sponge is fastened may be successfully used; in others, a long flexible sound, with a skein of thread attached to its extremity, may prove of service. The skein of thread forms a great number of loops, in some of which the foreign substance may be entangled. The probang thus furnished should be carefully passed beyond the supposed situation of the foreign body, and gently rotated during its withdrawal. The "horse-hair" probang (Fig. 159) may be used in a similar manner. The instrument is passed beyond the foreign body in the condition shown in Fig. 159; then, by pulling the handle *a*, the horse-hair is made to spread out, as shown in Fig. 160. On gently rotating the instrument during withdrawal the foreign body may be caught and removed.

It must be borne in mind that pointed substances are most likely to stick when they go with their points downwards; and that therefore attempts to push them on may often only result in burying them more deeply in the tissues. In some instances, however, in which the bodies are small and flexible, as herring-bones, bristles, etc., they

[1] Med. Times and Gaz., 1868, p. 447.

[2] Pathological Catalogue of Royal College of Surgeons, vol. iii., p. 28.

may be safely pushed on. It occasionally happens that this is most easily effected by making the patient swallow a large bolus of food, and immediately afterwards a draught of water.

Figs. 153, 154.

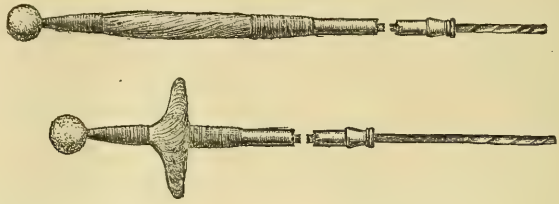


Fig. 153. Horse-hair Probang. Fig. 154. Horse-hair Probang, expanded.

Coins and such like bodies may often be extracted with comparatively little difficulty by means of a flat blunt hook connected by a thin slip of steel to the end of a long whalebone probang. (Fig. 155, *b*).

Fig. 155.

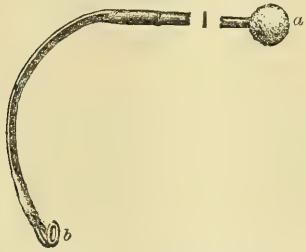


Fig. 155. Probang with sponge at end *a*. Money-probang at end *b*.

latter form is the more readily applicable. The best mode of construction for the œsophageal forceps is that devised by MM. Robert et Collin of Paris, modified and improved by Messrs. Mayer and Meltzer of London. Fig. 156 illustrates the principle upon which these forceps are made. It will be seen that very slight separation of the handles causes very wide separation of the blades.

The forceps, well oiled and with the blades closed, should be passed gently through the pharynx, and along the œsophagus, and used as a sound or probe until the foreign body is touched. The blades may then be opened, and an attempt made to seize the foreign body. Should the attempt be successful, the foreign body may be withdrawn; but in doing this the greatest delicacy and the most careful manipulation are necessary in order to avoid lacerating the mucous membrane.

In some cases, if the stomach is full and no other means are at hand, vomiting may be excited, in the hope that the ejection of the contents of the stomach may dis-

Fig. 156.

Fig. 156. Forceps for Extraction of Foreign Bodies.

If the foreign body is large and hard, with rough angular surfaces or projecting points, as a piece of glass or stone, or a fragment of bone of considerable size, it should always be extracted if possible. Long, properly curved forceps are most likely to be of service in such a case. The œsophageal forceps ordinarily made are of two kinds: in one the blades open laterally, and in the other antero-posteriorly. In some cases the former, in others the place and expel the extraneous substance. But this treatment is rarely successful. If the body is of large size and firmly impacted, and especially if its surface is rough or angular, continued and violent vomiting is not unlikely to give rise to laceration of the œsophagus. And if the body is small and pointed, vomiting may only render it more firmly fixed. But although, therefore, the administration of emetics cannot as a rule be recommended, it is right to

state that cases are on record in which large portions of meat, impacted in the pharynx and producing urgent symptoms of suffocation, have been got rid of by vomiting induced by the injection of a solution of tartarized antimony into the arm.[1] Other cases are recorded in which tartarized antimony and sulphate of zinc administered internally have led to satisfactory results.[2]

In some cases in which small bones have been lodged in the œsophagus it would appear that the constant swallowing of the dilute mineral acids has been of benefit. Professor W. Hall, of Baltimore, observes: "When a small bone is lodged in the fauces or œsophagus, it may be decomposed, or rendered so flexible that it will pass into the stomach, by the patient frequently taking diluted mineral acids. By this means I have succeeded in removing a small chicken-bone from the œsophagus, across which it had remained firmly fixed for several hours, although an emetic had been administered, and the curved forceps and probang had been frequently used, without success." It is right to allude to this method of treatment, but I venture to think it would be wrong to recommend its adoption.

When a foreign body, lodged in the œsophagus high up, obstructs respiration by pressure upon the trachea, tracheotomy must be performed. It may be possible to open the air-tube below the point where it is compressed. But even if this is impossible, an elastic tube may be passed down through the opening made, and respiration may be relieved until the foreign body can be removed.

Œsophagotomy.—If a foreign body in the œsophagus or pharynx can neither be extracted nor pushed down, nor got rid of by any ordinary means, it should be removed by operation, without unnecessary delay. It is true that in some cases extraneous substances have remained in the œsophagus during very long periods without producing much distress, or occasioning any serious injury to the neighboring parts. But it is equally true that in a large proportion of cases extensive suppuration and ulceration and very frequently fatal results have ensued. On the other hand the operation of œsophagotomy, or pharyngotomy, for the removal of foreign bodies has hitherto proved eminently successful. This operation may appear formidable in conception; but practically it is not difficult in execution, nor is it necessarily accompanied by any great risk. Experience shows that the chief danger is in delay. This is very forcibly urged by Dr. Cheever, of Boston, U. S., in an excellent monograph on Œsophagotomy recently published.[1]

Mr. Cock, referring to the recorded cases, writes: "It would appear that success has attended a speedy operation, whereas in those instances in which the use of the knife has been delayed until local inflammation, suppuration, or even sloughing has been established, and the patient's powers have been prostrated by fasting, pain, and want of rest, the operation has been fatal."[2] Again, Mr. Arnott, who was the first in this country to urge the importance and demonstrate the practicability of this operation, writes: "The rule of practice ought to be, when a solid substance, though only of moderate size and irregular shape, has become fixed at the commencement of the œsophagus, or low down in the pharynx, and has resisted a fair trial for its extraction or displacement, that its removal should *at once* be effected by incision, although no urgent symptoms may be present."[3]

It is probable that further experience will prove that the operation may be advantageously performed even in cases in which the foreign body is much lower down in the œsophagus than indicated in the above quotation. Indeed, in one of Mr. Syme's cases the foreign body was opposite the top of the sternum, and in one of Dr. Cheever's just below the top of the sternum.

More or less complete details have been published of 21 cases of œsophagotomy for the removal of foreign bodies. A summary of them is appended in a tabular form, pp. 912 et seq. Of the 21 cases 17 were perfectly successful, and followed by recovery. In 4 cases the patients died. But in these cases the foreign bodies were removed, and in no instance could death be attributed in any degree to the operation. In one case (Mr. Arnott's) the patient died of pneumonia, which existed before the operation was performed. In two cases (Demarquay's and Flaubert's) abscesses already existed. Respecting the fourth fatal case (Dr. Martini's) Mr. Cock[4] makes the following remarks, the justice of which will scarcely be disputed: "When we read that the man was repeatedly bled, that sixty separate attempts at dislodgment were made with levers and forceps, that enemata of belladonna were employed, that finally tartar emetic was injected into the veins, followed up by clysters of vinegar and opium to counteract its effects; moreover, that during this ordeal the patient was unable to swallow even a drop of water, it is not surprising that he finally succumbed."

[1] Dict. des Sciences médicales, t. vii., pp. 21, 22.

[2] Cooper's Dictionary, 7th edit., p. 1026.

[1] Two Cases of Œsophagotomy for the Removal of Foreign Bodies, with a History of the Operation, by D. W. Cheever, M.D. 2d edit. Boston, 1868.

[2] Guy's Hospital Reports, 3d Series, vol. xiii., p. 8.

[3] Med.-Chir. Trans., vol. xviii., p. 93.

[4] Guy's Hospital Reports, 3d Series, vol. iv., p. 230.

Method of operation.—The side of the neck upon which it is better to operate, and the exact situation in which it is best to make the incision, depend upon circumstances. If on external examination the foreign body can be felt projecting on one side, the incision should be made on that side and directly over the projection. If, however, the foreign body does not project on one side more than on the other, it is better to operate on the left side, inasmuch as the œsophagus inclines rather to the left, and this side of the neck is in some respects the more favorable for the manipulation of the surgeon. The patient should lie upon his back, the head and shoulders should be slightly elevated, and the face turned somewhat towards the opposite side. An incision four or five inches in length should first be made through the integuments over the depression between the sterno-mastoid and the windpipe. The incision should extend from about opposite the upper border of the thyroid cartilage nearly as low as the sterno-clavicular articulation. The platysma myoides muscle and the cervical fascia are then to be divided. The edges of the wound being held apart, the omohyoid muscle may be drawn outwards or cut through. The outermost fibres of the sterno-hyoid and the sterno-thyroid muscles may be divided to such an extent as may be necessary. The carotid sheath, with the contained vessels, thus fully exposed, should next be carefully drawn outwards together with the sterno-mastoid, and retained by means of blunt retractors; and the thyroid body should be separated so far as may seem necessary and drawn inwards. The separation of these parts is best effected by means of the handle of the scalpel, or a round-edged scalpel, or simply by the fingers.

The larynx being now drawn somewhat forwards, and turned slightly upon its long axis, the finger may be passed behind it; and an attempt made to discover the position of the foreign body. If this cannot be done, a long pair of curved forceps should be introduced by the mouth, passed well down into the pharynx, and then opened, and made to press the walls of the tube well towards the wound. A good guide is thus insured. [This is seldom needful.] An opening large enough to admit the finger should next be made into the œsophagus or pharynx. This opening may afterwards be extended upwards or downwards if necessary.

Lastly, the foreign body should be searched for with the finger, and when found, extracted by means of appropriate forceps. Any small bloodvessels, divided during the operation, should be at once tied. In the latter stages of the operation great care must be taken to avoid the recurrent laryngeal nerve, which ascends in the groove between the trachea and œsophagus. The wound should not be closed by sutures.

For the first few days after the operation the patient should be fed through an elastic catheter, or small œsophagus-tube, passed through the mouth into the œsophagus beyond the wound. In a few days the ordinary œsophagus-tube may be used.

Such is a brief description of what is doubtless the best method of performing œsophagotomy. This method at any rate has been adopted with unvaried success by Cock, Syme, and Cheever;[1] and certainly in the two cases in which I had the opportunity of seeing Mr. Cock operate, was carried out without any great difficulty.

Nélaton, who, however, writes apparently without any practical experience of the operation, and at the same time seems to entertain an exaggerated idea of its difficulty and danger, recommends a different method. He advises[2] that the incision be made in the median line, as in tracheotomy; that the sterno-hyoid muscles be separated, and the isthmus of the thyroid body be divided between two ligatures tied round it; and finally that the left lobe of the thyroid body be turned over, and the œsophagus sought and opened behind, and to the left of the trachea. This method would certainly appear to be much more difficult, if not more hazardous, than the lateral method, and also must be more liable to endanger

Fig. 157.

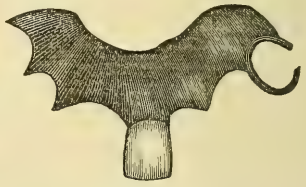


Fig. 157. The Tooth Plate and Tooth extracted in Mr. Cock's First Case of Œsophagotomy.

Fig. 158.

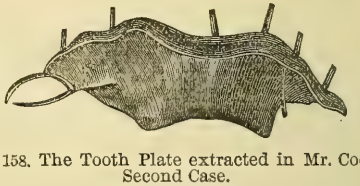


Fig. 158. The Tooth Plate extracted in Mr. Cock's Second Case.

the recurrent laryngeal nerve. It is worthy of note that this nerve, as a rule, has escaped serious injury. In one of Mr. Cock's

[1] See appended Table of Cases.

[2] Éléments de Pathologie chirurgicale, t. iii., p. 407.

cases, the patient before the operation had an excellent tenor voice; afterwards, he could only sing bass.

The accompanying woodcuts (FIGS. 157, 158) represent pretty accurately the tooth plates removed by œsophagotomy by Mr. Cock, to whose kindness I am indebted for permission to insert them in these pages. They serve to illustrate the general character of the foreign bodies that are most likely to render this operation necessary. When once such a body has become firmly impacted in the œsophagus, any attempt to remove it by forceps through the mouth must be wellnigh hopeless; and to push it forcibly onwards must be extremely dangerous. On the other hand, ample experience shows that the early performance of œsophagotomy is likely to be attended by the most perfect success.

Œsophagotomy has been several times practised in cases of disease, with the view of establishing an opening through which to convey food to the stomach. But in no instance has any satisfactory result been achieved.[1] In such cases, therefore, experience as well as *a priori* reasoning would seem to be opposed to the operation. [In a case which occurred lately in this city, a surgeon having performed œsophagotomy on account of a stricture, afterwards passed the tube, as was thought, down the gullet; meeting with an obstruction, the instrument was forced beyond, and a quart or so of beef-tea and milk was then passed through the tube; the patient died in a few hours, when it was found that the instrument had been driven along the outside of the œsophagus and through the diaphragm, and the food had been emptied into the peritoneal cavity.]

In the following table are summarized the details of all the cases of œsophagotomy for the removal of foreign bodies, which so far as I can ascertain, have hitherto been published. In compiling it, free use has been made of the table in Dr. Cheever's excellent monograph, than which, however, it will, I believe, be found more correct.

[1] See Dublin Journal, May, 1845. Journal de Chirurgie, par Malgaigne, t. iii., 1845, p. 371. Bruns, Deutsche Klinik, 1865, p. 37. A remarkable case quoted at length in the Sydenham Society's Year Book, 1866. These cases are referred to by Cheever. An additional case is recorded by Mr. Willett, St. Bartholomew's Hospital Reports, vol. iv., 1868, p. 204.

Table of Cases

In which the Operation of Œsophagotomy has been performed for the Removal of Foreign Bodies.

No.	Date.	Sex and Age.	Nature of Foreign Body.	Point of Impaction.	Treatment before Operation.	Operation, when performed, etc.	Result.	Cause of Death.	Operator and Authority.
1	1738	M.	Portion of bone, one inch long, six lines broad.	Œsophagus; exact point not stated.	Not mentioned.	Operation performed, and foreign body extracted.	Recovery.		M. Goursauld, "Mém. de l'Acad. de Chirurgie," t. iii., 1778, p. 14.
2			Probably a portion of bone.			Operation performed.	Recovery.		M. Roland, ibid.
3	1832	M.	Portion of beef-bone.	In œsophagus at lower part of neck.	Attempts made to dislodge it; body touched.	Operation on twelfth day after accident; bone extracted with difficulty, on left side of neck.	Speedy recovery.		M. Bégin, "Journ. univ. et hebdom.," 1833, t. xi., p. 93.
4	1832	M.	Large conical fragment of bone.	Œsophagus; lower part of cervical portion.	Every means attempted to dislodge it; body touched.	Operation on eighth day after accident, on left side of neck.	Recovery.		M. Bégin, ibid.
5	1833	2½	Spinous process of one of the dorsal vertebræ of a sheep.	Lower part of pharynx.	Emetics, and various attempts to dislodge it.	Operation not allowed until five weeks after impaction; incision on right side.	Death, fifty-six hours after operation.	Pneumonia, which existed at time of operation.	Mr. Arnott, "Med.-Chir. Trans.," vol. xviii.
6	1842	M. 41	Portion of bone, dense, triangular; angles sharp.	Œsophagus—perforation of; body lying on carotid.	Repeated attempts at extraction. Frequent hemorrhage.	Operation eighth day. On left side.	Recovery by the twenty-sixth day.		De Lavacherie, "Mémoires de l'Académie Royale de Médecine de Belgique," t. i., 1848, p. 126.

7	1811	M. 34	Portion of bone.	Could be felt from the exterior, projecting above the clavicle.	Bleeding, injection of tartar emetic in veins, enemata of belladonna, and sixty attempts at dislodgment by various instruments.	Operation four days after impaction; bone swallowed by patient during its performance.	Death, two days after the operation.	Collapse. Pharynx gangrenous. Stomach and duodenum inflamed.	Dr. Martini, "Journal de Chirurgie," par Malgaigne, t. iii., p. 336.
8	1853	M.	Small fish.	Pharynx; tail seen in mouth.	Vain attempts at withdrawal through mouth.	Operation after several days.	Recovery in six weeks.		Antoniesz, "Lancet," vol. ii., 1854, p. 260. (From "Ceylon Miscellany," vol. i., No. 2).
9	1853	M. 44	Fragment of beef-bone.	Œsophagus in neck.	Vain attempts at extraction.	Operation on ninth day.	Death on second day after the operation.	Perforation in front and behind. Retro-pharyngeal abscess reaching to stomach.	Flaubert, "Gazette des Hôpitaux," 1857, No. 88, p. 349.
10	1854	F. 3½	Franc piece.	Upper part of œsophagus.	Repeated attempts at extraction with Graefe's sound and forceps.	Operation on tenth day.	Death third day after operation.	Retro-œsophageal abscess opening into pleura.	Demarquay, "Gazette hebdom.," Nov., 1861, p. 701.
11	1855		Portion of bone.	Œsophagus: abscess formed.	Could not be reached through mouth.	Operation on sixteenth day.	Recovery in two weeks.		Syme, "Clinical Surgery," Edin., 1861, p. 91.
12	1856	M.	Gold tooth-plate, containing one false incisor.	Junction of pharynx and œsophagus. No external projection.	Vain attempts at removal with forceps and other instruments; emetics.	Operation on fourth day; incision on left side.	Recovery in four weeks; voice permanently altered from tenor to bass.		Cock, "Guy's Hospital Reports," series iii., vol. iv., 1858, p. 217.

TABLE OF CASES—*Continued.*

No.	Date.	Sex and Age.	Nature of Foreign Body.	Point of Impaction.	Treatment before Operation.	Operation, when performed, etc.	Result.	Cause of death.	Operator and Authority.
13	1861		Thin piece of mutton-bone, one inch square.	Œsophagus; no external projection.	Could not be reached from mouth.	Operation on sixth day.	Recovery in two weeks.		Syme, "Clinical Surgery," 1861, p. 94; "British Medical Journ.," 1861, p. 91.
14	1862	M. 21	Swedish copper coin, size of old penny.	Œsophagus; opposite upper part of sternum.	Coin had passed into gullet in November; in three weeks, symptoms of obstruction disappeared and patient was discharged. Re-admitted in February, still feeling something in gullet. Coin touched by bougie.	Operation more than two months after the accident.	Recovery; could swallow in a week. Convalescent in a fortnight.		Syme, "Edinburgh Medical Journal," 1862, vol. vii., part ii., p. 1010.
15	1863	M. 22	Fragment of bone 35 mm. in length, 24 in breadth, 10 in thickness. Nature of body not suspected. Said to have been swallowed in a portion of bread.	Commencement of œsophagus.	Emetics; sound detected foreign body, the size and nature of which could not be made out. Attempts at removal by forceps, and at pushing down by probang, unsuccessful.	Operation sixth or seventh day, by lateral method.	Recovery; no bad symptom. Fed by tube for ten days. Wound perfectly healed in six weeks.		Sonrier, "Gazette des Hôpitaux," 1864, p. 66.
16	1864	F.	Peach-stone.				Recovery.		Arnold, "F. C. Morgagni," vi., 1864, p. 352. (Quoted on the authority of Cheever.)

17	1866	M.	Portion of fin-bone of codfish, one-half inch by one-fourth inch.	Junction of pharynx and œsophagus. No external projection.	Spontaneous vomiting; pharynx explored by finger and probang, causing rigors.	Operation on third day; incision on right side.	Recovery in six weeks.		Cheever, "On Œsophagotomy for the Removal of Foreign Bodies," Boston, 1868.
18	1866	M.	Brass pin, one inch and a quarter in length.	Just below top of sternum. No projection.	Vomiting; long probang passed without obstruction.	Operation on third day; incision on left side.	Recovery in five weeks; no adhesions.		Cheever. Ditto, ditto.
19	1867	M. 33	Silver tooth-plate, adapted to portion of gum occupied by upper incisors and canines, with projecting rivets upon which the false teeth were formerly fixed.	Junction of pharynx and œsophagus.	Repeated attempts with probang, forceps, etc. Could be grasped by the forceps, but not moved.	Operation on fourth day.	Recovery; could swallow milk on the fourth day, solids on eighth day; discharged well on fifteenth day; no permanent alteration of voice.		Cock, "Guy's Hospital Reports," series iii., vol. xiii., p. 1.
20	1867	F.	Brass pin.	Apparently opposite left side of cricoid.	Attempts during four months.	Operation after four months.	Recovery.		Hitchcock, "Boston Medical and Surgical Journ.," July 16, 1868.
21	1868	F.	Supposed to be a pin.	Junction of pharynx and œsophagus.	Various attempts.	Operation after eight months, left side.	Recovery.		Cheever, op. cit., p. 32.

In neither of the last two cases was any foreign body found. They are only quoted here as illustrating the small degree of risk incurred in this operation. Out of the twenty-one cases, seventeen were followed by recovery; and in the four in which death occurred, the complications which proved fatal existed before the operation was performed.

Injuries of the Pharynx and Œsophagus produced by Concentrated Acids and Caustic Alkaline Solutions.

Concentrated acids and caustic alkaline solutions are sometimes swallowed accidentally and sometimes with suicidal intent. The effects produced vary with the nature, quantity, and strength of the fluid swallowed, and also to some extent with the amount of food, etc., in the stomach at the time. If the poison, whether acid or alkaline, is very concentrated, and taken in large quantity, more or less complete destruction of the mucous membrane of the pharynx, œsophagus, and stomach commonly results. The stomach (especially if empty) may be perforated, and the neighboring parts seriously implicated. In such cases death usually ensues in from eighteen to twenty-four hours or less. If the poison is more diluted, violent inflammation of the mucous membrane of the fauces and œsophagus is excited. Lymph is effused on the surface, and into the submucous areolar tissue. Pain and difficulty in deglutition result. Ulceration often occurs, and is followed by thickening of the walls of the œsophagus, and constriction of its calibre. In some such cases slow recovery takes place; but much more frequently the constriction remains permanent; and finally the obstruction becomes impassable, and the patient dies of starvation.

When one of the concentrated mineral acids is swallowed, the patient immediately suffers violent burning pain in the fauces, œsophagus, and stomach. The mucous membrane of the lips and the mouth is excoriated or corroded, and appears whitish or yellowish in color. Sometimes it resembles soaked parchment. In one instance (mentioned by Dr. Taylor)[1] in which sulphuric acid had been taken, "the appearance of the mouth was as if it had been smeared with white paint." Thick, ropy, mucous stuff, consisting of saliva, mucus, and corroded membrane, escapes from the mouth. Retching and vomiting come on almost at once, and continue incessantly, or are easily re-excited by attempts to swallow.[2] Whatever is swallowed is immediately ejected. The vomited matter is usually more or less viscid, and of a dark coffee-grounds color. There is generally great difficulty in speaking and swallowing, and sometimes in breathing, from swelling of the mucous membrane of the fauces and larynx. The countenance becomes more or less livid, the skin cold and clammy, and the pulse quick, small, and feeble, or almost imperceptible. There is usually considerable thirst; the bowels are constipated, and if any evacuations take place, they are commonly either of a dark brown or leaden color, but in some instances almost black from an admixture of altered blood.[1] There is great physical anxiety and distress; but the intellectual faculties, as a rule, remain clear. Exhaustion advances speedily; and death often occurs very suddenly.

After death, the mucous membrane of the mouth and tongue is found to be whitish, or yellowish, and more or less softened and corroded. If nitric acid has been taken, the characteristic yellow staining to which it gives rise may sometimes be recognized. The mucous membrane of the pharynx and œsophagus is corroded, and of a brownish or ash-gray color; sometimes it appears blackish and charred in spots and patches, and under such patches effused blood is found. Cases, however, have been met with, in which the mouth, throat, and gullet, have escaped almost uninjured.[2] The stomach is sometimes softened and perforated; but if not, it is generally collapsed and contracted. Its mucous membrane is intensely inflamed throughout or in parts; and is often covered by dark brown or black pitch-like stuff, which consists of mucus and altered blood. When this stuff is removed, the mucous membrane may be seen to be traversed by blackish or dark crimson lines of inflammation.[3]

If the patient recovers from the immediate effects of the injury, he is still liable to suffer from various more or less remote effects, which may give rise to prolonged suffering, and ultimately prove fatal. Among such may especially be mentioned ulceration and constriction of the stomach, with permanent impairment of its functional power, and stricture of the œsophagus.

Dr. Wilson[4] has recorded an interesting case, in which death resulted from the effects of sulphuric acid swallowed forty-five weeks and three days previously.

Six months after the acid was swallowed the patient ejected, during a violent fit of cough-

[1] Medical Jurisprudence, by A. S. Taylor, M.D. [8th Am. ed., 1880, p. 106.]

[2] "In a case of poisoning by sulphuric acid, reported by Dr. Geoghegan, the patient vomited for three or four hours. This symptom then ceased, and did not recur, although the woman did not die until thirty-four hours after the poison had been swallowed." Medical Gazette, vol. xlviii., p. 328.

[1] Taylor. [8th Am. ed., p. 107.]

[2] See cases by Dr. Ogle, Med. Times and Gazette, April 21, 1860. Mr. Dickinson, Lancet, 1853, p. 502, etc., quoted by Taylor.

[3] For numerous illustrative cases, see Taylor, Med. Jurisprudence; Taylor On Poisons, i.; Guy's Hospital Reports, Series I., vol. iv., p. 10, p. 297; Series II., vol. iv., p. 396; vol. v., p. 167; vol. vii., p. 211; Series III., vol. v., p. 134. Casper's Forensic Medicine (Sydenham Society's Translation), vol. ii., p. 75.

[4] Medico-Chirurg. Trans., vol. xxi.

ing, a cylindrical tube eight or nine inches in length. The chief symptoms which subsequently occurred, and preceded death, were great difficulty in swallowing, pain extending from the pit of the stomach to the shoulders, and expectoration, at intervals so copious that as much as two pints of frothy mucus were discharged in the course of twenty-four hours.

When a strong alkaline solution is swallowed, the patient experiences an acrid caustic taste, followed by a sensation of burning heat extending from the throat to the stomach. Vomiting sometimes occurs, but not always. The ejected matters are generally of a dark brown color, and mixed with blood and shreds of membrane. The surface becomes cold and clammy, and the pulse quick and feeble. But in some cases intense heat of skin has been noticed.[1] There is often more or less purging, and colicky pain in the abdomen. "In the course of a short time, the lips, tongue, and throat become swollen, soft, and red."[2] Death may occur within a few hours; or the immediate effects of the injury may be recovered from.

The post-mortem appearances ordinarily found in cases in which death has speedily resulted, are as follows. The mucous membrane of the mouth, pharynx, and gullet, presents more or less manifest indications of the local action of the caustic. Sometimes it is inflamed; and patches of a dark chocolate or blackish color are seen; sometimes it is softened, and detached. The mucous membrane of the stomach is partially inflamed, and may be eroded in places; or it may be puckered and blackened.

In the case of a child, a year and a half old, who died in Guy's Hospital twelve hours after having swallowed a mouthful of soap-lees, the following appearances were found.[3] "The mouth and tongue were slightly excoriated and of a light-brown color. The mucous membrane of the fauces, tonsils, and pharynx, had a slightly swollen appearance, and was of a similar yellowish-brown hue. The whole of the œsophagus was in a somewhat similar condition, the mucous membrane having a brownish color, particularly along the rugæ. The membrane was changed in character by the alkali, but nowhere destroyed. The greatest pernicious effect had been produced at the very extremity of the œsophagus, where the interior was of a dark-brown color; this terminated at a definite line, the mucous membrane of the stomach immediately below being quite unaffected . . . . Near the pyloric end of the stomach, there were a few rugæ of a very dark-brown color, produced, no doubt, by the action of the alkali. The mucous membrane thus altered was not at all soft; nor could it be stripped off, but on the contrary was hard and had a horny feel . . . . The larynx was almost closed above by the greatly swollen epiglottis. Upon raising the epiglottis, and looking into the larynx, the passage was seen to be quite free, the vocal cords not having been touched."

The following case, recorded by Dr. Barclay,[1] furnishes a good illustration of the after-effects that may result from swallowing a strong alkaline solution.

A woman, aged forty-four, was admitted into St. George's Hospital on May 2, 1853, about six hours and a half after having swallowed a quantity of "American potash"—probably a saturated solution of carbonate of potash. She had vomited directly after taking it. The mouth and fauces were much corroded.

On introducing the tube of the stomach-pump some shreds of softened mucous membrane clung to it. There was great pain in the fauces, œsophagus, and at the epigastrium, but no tenderness on pressure. There was a little vomiting two days after admission. Deglutition was difficult; and pain was felt after the passage of food into the stomach. At the beginning of June, there was frequent vomiting, pain in the abdomen, tenderness on pressure, and constipation. After a time nothing could be retained in the stomach; food and medicine caused much pain, and were soon rejected. The patient, during a short period before death, was sustained by nutritive enemata. She died of inanition, July 8, about two months after having taken the alkali. On inspection, there were found at the upper part of the œsophagus, opposite the cricoid cartilage, three dense cicatrized bands, apparently the results of previous ulceration. The lower part of the œsophagus was much contracted, the lining membrane being entirely destroyed, and the muscular coat exposed. The external coats were much thickened. The cardiac orifice of the stomach, where the ulceration ceased, was so much contracted as hardly to admit a director. At the pyloric end the mucous lining presented a large and dense cicatrix, which obstructed all communication with the duodenum, excepting through an orifice no larger than would admit a probe. The intervening portion of the stomach was healthy—as were also the small and large intestines.

Dr. Basham[2] has recorded[1] a case in which the fatal result was still more remote. The patient accidentally swallowed some soap-lees. The first symptoms of irritation and inflammation subsided. Within a few weeks there was some slight difficulty in swallowing; but it was not until eleven months afterwards that the dysphagia became very severe. Death did not occur until two years and three months after the accident. There was very tight stricture of the œsophagus. The stomach was unaffected.

Strong solutions of ammonia, when swallowed, produce effects very similar to those

[1] This symptom was especially observed in the case of the child whose symptoms are detailed in the text. See Guy's Hospital Reports, 3d Series, vol. v., p. 133.

[2] Taylor, op. cit. [8th Am. ed., p. 122.]

[3] Guy's Hospital Reports, 3d Series, vol. v., p. 133.

[1] Medical Times and Gazette, 1853, p. 554.

[2] Lancet, March 2, 1850. Med.-Chir. Trans., vol. xxxiii. In this paper short records are quoted of cases under Sir C. Bell, Mr. Cumin, and Mr. Dewar.

caused by solutions of potash and soda; but the sense of heat and the burning pain are more intense in the former than in the latter case. Ammoniacal solutions, furthermore, are especially liable, from the volatility of the gas, to affect the respiratory organs. In some cases it may be difficult to decide whether death has resulted from suffocation, from shock, or from the immediate effects of damage to the mucous membrane of the alimentary canal.

Christison refers to a case in which a strong dose of solution of ammonia caused death by suffocation in four minutes. In another instance a man suddenly swallowed a drachm and a half of liquor ammoniæ. He fell instantly to the ground, and soon died, after suffering the most excruciating pain.[1] In a case that came under the observation of Mr. Hilton,[2] a gentleman swallowed a quantity of strong solution of ammonia in mistake for sal volatile. The mucous membrane of the mouth and throat was corroded and dissolved. The difficulty of breathing was very great. Death occurred on the third day. On post-mortem examination the mucous membrane of the gullet was found to be softened, and at the lower part near the junction with the stomach was completely dissolved and destroyed. There was an aperture in the anterior wall of the stomach, through which the contents had escaped. The mucous membrane presented a blackened and congested appearance, resembling that produced by sulphuric or oxalic acid. The immediate cause of death was believed to have been obstruction of the air-tubes resulting from inflammation. "The lining membrane of the air-passages was softened and covered with layers of false membrane, and the larger bronchi were completely obstructed by casts."

The following case illustrates the more remote effects of swallowing a strong ammoniacal solution.

A female, aged nineteen, was admitted into St. George's Hospital on September 2, 1853, who, eight weeks previously, while in an unconscious state, had been made to swallow a quantity of hartshorn. She immediately felt severe pain in the stomach, and in an hour or two became sick and vomited some blood. Hæmatemesis continued during three days. From the first there was great irritability of stomach, and constant rejection of food. The bowels were constipated. There was great emaciation and loss of strength. Death from starvation occurred three months after the poison was swallowed. On inspection, the œsophagus was found to be healthy, excepting at the cardiac orifice, which was slightly contracted. On the posterior wall of the stomach was a dense cicatrix of the size of half-a-crown, and from its margins fibrous bands diverged in various directions. The pyloric orifice was contracted to the size of a crowquill. The other parts of the intestinal canal were healthy.

Treatment.—The poison, whether acid or alkaline, should be neutralized, and its immediate effects obviated, as speedily and as completely as possible, by aid of the stomach-pump. A large quantity of water, or other diluent, as milk, thin gruel or barley-water, should be introduced into the stomach, and then pumped out. If acid has been taken, carbonate of soda, or magnesia, should be mixed with the diluent in considerable proportion. Chalk and whiting, or the scrapings from a whitewashed wall or ceiling, are materials commonly at hand; and in many cases they are very appropriate. But if sulphuric acid has been taken, it must be recollected that lime compounds will form sulphate of lime, which from its rapid absorption of water may give rise to some difficulty, unless a large quantity of diluent is used, and the pumping out is rapidly accomplished. In some instances a solution of soap has been advantageously used. If alkali has been taken, vinegar or some other vegetable acid, if at hand, should be mixed with the diluent; or oil may be administered.

In many cases stains about the mouth, or on the clothes, indicate the nature of the poison that has been taken. Sometimes the patient is able and willing to give information. But if neither indication nor information is afforded it is better to introduce the diluent at once, and to ascertain, by pumping out some of the contents of the stomach, what neutralizing agent is required. The whole length of the œsophagus should be carefully washed.

When the stomach has been completely cleared of the poison, means should be adopted to allay the sufferings of the patient, and to prevent as far as possible the supervention of dangerous inflammation. Opium may be administered in the form of suppository; or morphia may be given subcutaneously. Hot anodyne and counter-irritant fomentations may be applied over the stomach; and, somewhat later, leeches may be of service. Food should be given very sparingly, or not at all, for some short time. The more perfectly at rest the injured parts are kept the better. Demulcent drinks, as milk, barley-water, etc., may be supplied to allay the thirst so often experienced. Nutrient enemata, with opium, may be advantageously given.

When the first inflammatory symptoms have subsided, an œsophageal bougie should be passed, even before symptoms of dysphagia appear. The use of the bougie should be continued daily during a considerable period. If the quantity and strength of the poison swallowed, and the symptoms that have arisen, render it probable that the œsophagus has been severely injured, it is desirable to pass the bougie at intervals, long after there is any apparent necessity. In such cases experience shows

[1] Journal de Chimie médicale, 1845, p. 531.

[2] Described in detail by Taylor. [8th Am. ed., p. 124.]

that stricture of the œsophagus is almost certain to occur, sooner or later, however slowly and insidiously it may come on.

If the occurrence of stricture has not been prevented, it is of the greatest importance to recognize its existence at the earliest possible period, and to adopt proper treatment without delay.

If recognized early, strictures of the œsophagus resulting from the injuries under discussion may generally be dilated by the passage of bougies. The bougie should be shortly conical at the extremity. It should be passed with caution into the stricture, and retained there for ten minutes or a quarter of an hour at a time, or even longer if it can be borne. Or a small cylindrical bougie may be passed, if possible, through the stricture, and similarly retained. The introduction of the bougie must be repeated daily.

Great perseverance and patience are requisite. Mr. Cumin[1] records a case in which stricture of the œsophagus resulted from the effects of "American potash," swallowed by mistake. The passage of bougies ultimately proved very successful. But unremitting attention was requisite during ten months before normal deglutition was restored. Mr. Hutchinson[2] relates a case under the care of himself and Mr. Mead, of Hackney, in which a satisfactory, though perhaps less completely successful result was obtained in a much shorter time. The patient had accidentally swallowed some caustic potash three months previously. The symptoms of contracting stricture of the œsophagus steadily developed themselves. When seen by Mr. Hutchinson, the patient seemed rapidly sinking. She had swallowed nothing for several days. Attempts were made to pass bougies of various sizes, under chloroform. The upper of two strictures which existed was passed by a large bougie; but a No. 8 catheter would not even enter the lower one. The next day, however, the patient was able to swallow a little fluid nourishment. Ten days later, the end of a No. 6 urethral bougie was passed well into the stricture, but not through it. During the week following, food was taken fairly, and the patient improved in condition. The improvement continued. A year subsequently the stricture still existed, and solids could only be swallowed when carefully minced; but the patient was in better health than she had been for years.[3]

Such cases may well serve to encourage the surgeon in the persevering use of bougies.

In some instances it would appear that the administration of mercury and chalk combined with Dover's powder has been beneficial.

Gastrotomy.—It sometimes happens, either in consequence of the age or condition of the patient, or of the extent or impermeability of the stricture, that all attempts at dilatation by bougies are in vain. In such case the patient must inevitably die of starvation unless an artificial way into the stomach can be established.

Now it has been abundantly proved by operations for the removal of foreign bodies that the stomach may be opened with comparative impunity.[1] Numerous cases are on record in which wounds implicating the stomach have been followed by permanent fistulæ. And further, no difficulty has been experienced in establishing fistulous openings into the stomachs of healthy animals for purposes of physiological research. The consideration of these and such like facts has suggested, and would seem to justify, the attempt to make a new way into the stomach in any case in which the œsophagus is absolutely and permanently obstructed, whether by the effects of injury, or as the result of disease.

Sédillot, of Strasburg,[2] appears to have been the first to perform the operation of gastrotomy (or, as he terms it, *gastro-stomie*), on account of stricture of the œsophagus. Some years later, but without any knowledge of Sédillot's attempts, Dr. Habershon suggested, and Mr. Cooper Forster performed the operation for the first time in this country.[3]

About a year subsequently, Mr. Cooper Forster performed the operation in a second case, the particulars of which are especially deserving of quotation in these pages. The patient, a child four years and four months old, was admitted into Guy's Hospital, under the care of Dr. Addison, on February 2, 1859. Seventeen weeks previously he had swallowed some corrosive poison, supposed to be a solution of potash. Violent vomiting immediately occurred; and either at the time, or at a subsequent period, the vomited matter contained two or three teaspoonfuls of blood. Fifteen weeks after the accident marked dysphagia came on, and gradually increased in severity. On admission there was pain in the throat and epigastrium. The child was much emaciated. He had swallowed some beef tea two days previously, but nothing since. Injections of beef tea and wine were administered every four hours, and half a grain of calomel was given twice a day. During a fortnight or so improvement appeared to take place. But after a time the difficulty of swallowing again increased. On March 12, he was very much exhausted, and seemed to be sinking fast. He had not swallowed anything for two days. The next day gastrotomy was performed, un-

[1] See Dr. Basham's paper, Med.-Chir. Trans., vol. xxxiii.

[2] London Hospital Reports, vol. iv., p. 56.

[3] Mr. Meade kindly informs me that the patient is still in excellent health, and able to swallow fluids and minced meat with care. More than two years have elapsed since she was under treatment.

[1] See Table of Cases, p. 549.

[2] See the very elaborate and interesting chapter on the subject in Sédillot's Contributions à la Chirurgie, 1868, vol. ii.

[3] Guy's Hospital Reports, 3d Series, vol. iv., pp. 1–18.

der chloroform. Food was administered at frequent intervals through a tube passed into the stomach through the opening. The child seemed very comfortable, and enjoyed being fed. On the morning of the fourth day after the operation he suddenly complained of great pain over the abdomen: he became collapsed and cold, the eyes were sunken, and the pulse was almost imperceptible. He quickly sank into a comatose state, and died. On post-mortem examination, it was found that a large part of the œsophagus had been affected. The middle two-fourths were constricted by thickening and induration of the submucous tissue; and a small sloughy spot existed at the commencement of the strictured part of the tube. The wound in the abdominal parietes had begun to slough, and the stitches were loosened. Recent general peritonitis had resulted from escape of some of the contents of the stomach into the cavity. The mucous membrane of the stomach was healthy, but was dark in color round the opening.[1]

Before gastrotomy is attempted, care should be taken to ascertain that the stomach itself is comparatively healthy, and that all serious disease or constriction is confined to the gullet.

Method of operation.—The operation is performed in the following manner. Chloroform [ether] may be administered or not, according to circumstances. It should be given unless the patient can be relied on to remain perfectly still. Experience shows that troublesome vomiting is not so commonly produced as might be anticipated. The patient lies flat on his back in bed. The surgeon, standing on his right side, makes a perpendicular incision three or four inches in length through the integuments over the upper part of the left linea semilunaris. The aponeuroses of the abdominal muscles, and the transversalis fascia are then divided on a director to a corresponding extent. The outer border of the rectus muscle may or may not be seen.

The peritoneum is next opened, and the anterior wall of the stomach, which may be readily recognized, is brought into view. Or the great omentum may be seen lying in front of the intestines. In the latter case, gentle traction upon the omentum, and upward extension of the wound, may be requisite. The anterior wall of the stomach is then drawn well forwards into the wound, by means of strong silk ligatures passed through it, or by sharp hooks. An opening an inch in length is next made into the stomach midway between the greater and lesser curvatures, and as near the cardiac end as practicable. The opening should be perpendicular in direction. Care must be taken that none of the contents of the stomach escape into the peritoneal cavity. Lastly, the margins of the aperture are carefully sewed to the edges of the opening through the abdominal parietes by several stitches, or by an uninterrupted suture. It is very important to adapt accurately the cut edges of the mucous membrane to those of the skin. At least a third, or even half an inch, of the stomach-wall should be included in the sutures. The portions of the external wound above and below the part occupied by the stomach are closed by sutures. There is little or no difficulty in the accomplishment of the operation, and no immediate risk is encountered. Such is an outline of the method practised by Cooper Forster, and adopted by Sydney Jones, Curling, and myself. Sédillot[1] recommends a crucial incision through the upper part of the left rectus muscle. But this method does not appear to possess any special advantages, and it is open to several obvious objections.

After the operation, the patient may be fed at such periods as may seem desirable through a tube introduced into the stomach; or by means of a spoon, or some such instrument, nourishment may be poured in little by little. It would probably be better if the patient could be supported entirely by enemata for some days, so as to avoid disturbing the edges of the wound, and interfering with adhesion. Strips of oiled lint may be placed round the wound, and warm fomentations applied over the abdomen. Mr. Hutchinson[2] suggests that a large silver tube should be retained in the opening, and ice-bladders kept on the abdomen.

Gastrotomy on account of obstruction of the œsophagus, has been performed in nine cases, all of which have terminated fatally. Sédillot, Cooper Forster, and Sydney Jones, have each operated in two cases, and Fenger (of Copenhagen), Curling, and myself, in one case each. The particulars of these cases are summarized in the appended table. [For a successful case by Sydney Jones, see Lancet, May 15, 1875; by Verneuil, Med. Times and Gaz., Nov. 4, 1876.]

[1] Guy's Hospital Reports, 3d Series, vol. v., p. 1, et seq.

[1] Op. cit.

[2] London Hospital Reports, vol. iv., p. 58.

Table of Cases

In which the Operation of Gastrotomy has been performed on account of Stricture of the Œsophagus.

No.	Date.	Sex.	Age.	Nature of Stricture, etc.	Mode of Operation.	After-Treatment.	Result.	Cause of Death.	Operator and Authority.
1	1849	M.	52	Epithelial cancer of the œsophagus. Symptoms of obstruction of five months' duration; rapidly increasing in severity; great debility; absolute inability to swallow; passage of bougie impossible; frictions; local applications; nutrient enemata.	Chloroform given. Crucial incision through skin over rectus. Sheath and muscle similarly cut through, and peritoneum divided; great omentum exposed; by drawing this downwards, stomach brought into view; the greater curvature drawn up to the wound; anterior wall punctured midway between pylorus and cardiac end; canula introduced (so made as to hold the stomach in contact with the abdominal parietes); plug put into canula.	Warm fomentations over abdomen. Eau sucrée and beef-tea injected from time to time; greenish bile accumulated in the stomach, escaped when plug was withdrawn from canula; no pain; patient slept at intervals, and was comfortable during night; in the morning dyspnœa and quickness of breathing; rapid death.	Death fifteen hours after the operation.	Exhaustion. Slight indications of peritonitis.	Sédillot, "Contributions à la Chirurgie," t. ii., p. 484.
2	1853	M.	58	Malignant disease of the œsophagus, opposite the larynx: great dysphagia. Symptoms nine months.	A long incision on the left side, two fingers' breadth from the median line, and two centimètres below false ribs; a second incision, perpendicular to this, so as to make a cruciform incision. Stomach seized and fixed to abdominal wall by five or six points of suture carried through its peritoneal and muscular coats only; opening the stomach being postponed until it became united to the parietes. Chloroform given.	Two hours and a quarter after the operation, the stomach was partially torn from its connections by a fit of coughing, and passed into the abdomen; drawn out again, and fixed to the skin by Assalini's forceps. The part thus included became gangrenous, and when removed five days after the operation, the stomach was opened into. The surrounding adhesions were then firm. Through this fistulous opening, wine, beef-tea, milk, etc., were introduced, but they would not remain in the stomach.	Death ten days after the operation.	Exhaustion. Peritonitis.	Sédillot, "Gazette des Hôpitaux," p. 164, 1853; and op. supra cit., t. ii., p. 494.

TABLE OF CASES.—*Continued.*

No.	Date.	Sex.	Age.	Nature of Stricture, etc.	Mode of Operation.	After-Treatment.	Result.	Cause of Death.	Operator and Authority.
3	1854	M.	55	Obstruction of œsophagus from malignant tumor.	By transverse incision through left rectus muscle, along the cartilages of the ribs. Stomach drawn out, opened, and margin of the opening fastened to the parietes.	Consisted in preserving the stomach from the air by means of a bandage, with lint and gutta-percha over the wound, and giving nourishing fluids introduced through glass filter.	Death fifty-eight hours after the operation.	Exhaustion. No effusion into peritoneum; no peritonitis.	E. Fenger, "Archiv. für Path., Anat. und Physiol.," B. vi., p. 350, 1854.
4	1858	M.	47	Epithelial cancer of the œsophagus; complete obstruction of the canal, and consequent starvation.	Chloroform not given; operation as described in text. The orifice in the stomach was left about large enough to admit end of little finger.	Milk, eggs, and rum, in small quantities, administered every half hour, through an elastic tube passed into the stomach through the wound; great relief to patient.	Death forty-four hours after the operation.	Exhaustion. Peritoneum healthy; no inflammation nor effusion of lymph or serum.	Cooper Forster, "Guy's Hospital Reports," vol. iv., 1858, p. 13.
5	1859	M.	4 yr. 4 m.	Stricture of œsophagus from swallowing a solution of caustic alkali.	Chloroform given; no sickness produced; operation as described in text. Twenty-three weeks after swallowing the poison.	Milk and egg, and egg and wine, given alternately every hour, through a tube passed into the stomach through the wound, with nutritive injections of beef-tea.	Death on the morning of the fourth day after the operation.	Peritonitis following the giving way of the adhesions between stomach and abdominal parietes; caused probably by the slight force employed in introducing the feeding-tube.	Cooper Forster, "Guy's Hospital Reports," vol. v., 1859, p. 1.

6	1860	F.	44	Epithelial cancer, involving pharynx and larynx; complete obstruction of the œsophagus, and consequent starvation.	Operation as described in text. Difficulty in securing the cardiac end of the stomach, as it was drawn downwards, and more to the left than usual, by omental adhesion. Four ounces of blood lost during the operation.	Tube, with funnel fitted at the upper end, placed in the stomach through the wound, and retained there until the patient's death. No irritation produced by it. Milk and brandy in small quantities, with small doses of laudanum; nutritive enemata.	Death thirty-six hours after the operation.	Exhaustion. No peritonitis.	Sydney Jones, "Trans. Pathol. Soc.," vol. xi., p. 101.
7	1866	M.	57	Epithelial cancer of œsophagus; passage all but completely occluded; patient sinking rapidly.	Ether spray used; operation as described in text. Scarcely any bleeding.	Subcutaneous injection of morphia; warm milk and water introduced into stomach, but caused much pain. Intensely acid, viscid fluid welled out from the stomach; milk and beef-tea given through catheter every half hour; great relief; nutrient enemata also administered; no vomiting. Patient gradually sank.	Death thirty-two hours after the operation.	Exhaustion. No peritonitis.	T. B. Curling, "London Hospital Reports," vol. iii., p. 218.
8	1866	M.	61	Epithelial cancer of œsophagus, opposite upper border of sternum. Symptoms during five months; extreme dysphagia during ten weeks; liquid food returned, unless taken in very small quantity; the smallest bougie could not be passed.	Ether spray used; operation as described in text. Left lobe of liver exposed, under which the stomach fell, but was easily drawn forwards. Very little hemorrhage.	Subcutaneous injection of morphia; warm fomentations over abdomen; opening into stomach closed with oiled lint. Quarter of a pint of beef-tea or milk introduced through opening every two hours, alternately with egg and brandy; no pain; patient did well for some days, then symptoms of broncho-pneumonia appeared.	Death on the thirteenth day after the operation.	Broncho-pneumonia. No peritonitis. The edges of the opening into the stomach firmly united to the abdominal parietes.	Sydney Jones, "Lancet," vol. ii., 1866, p. 665.

TABLE OF CASES.—*Continued.*

No.	Date.	Sex.	Age.	Nature of Stricture, etc.	Mode of Operation.	After-Treatment.	Result.	Cause of Death.	Operator and Authority.
9	1868	M.	70	Epithelial cancer of œsophagus, about three inches below cricoid. Symptoms increasing in severity during some months; starvation impending; smallest bougie would not pass.	Chloroform administered. No sickness produced; operation as described in text. Scarcely any hemorrhage.	Warm milk introduced into stomach through elastic tube; immediately rejected; a quantity of brownish-green fluid welled up through the opening. Morphia administered subcutaneously. Warm fomentations to abdomen; nutrient enemata of brandy, beef-tea, and arrowroot. Sank suddenly.	Death sixteen hours after the operation.	Exhaustion. No signs of peritonitis. Viscera generally healthy.	A. E. Durham, "Guy's Hospital Reports," series iii., vol. xiv., p. 195.

TABLE OF CASES

In which the Operation of Gastrotomy has been performed for the Removal of Foreign Bodies.

No.	Date.	Sex.	Age.	Nature of Foreign Body, etc.	Mode of Operation.	After-Treatment.	Result.	Operator and Authority.
1	1635	M.		Knife, six and a half inches in length. Retained about six weeks.	By straight incision through left hypochondrium, two fingers' breadth, under false ribs. Wound joined by five sutures.	Tents impregnated with tepid balsam, and a cataplasm of bolar earth, white of egg, and alum applied.	Wound healed on the fourteenth day after the operation.	Sinoval, "Chelius's Surgery," Trans. by South, vol. ii., p. 391.
2	About 1743	F.		Knife swallowed eleven days previously. First three days no pain; then great suffering.	Incision through abdominal parietes on to knife, which could be felt projecting. The blade had penetrated the stomach, and caused slight suppuration. The knife extracted by forceps.		Rapid recovery.	Hubner, "Mém. de l'Académie royale de Chirurgie," 1743, t. i., p. 597. Quoted by Sédillot, op. cit., p. 461.

3		M.		Knife, nine inches in length, swallowed two months previously. Point could be felt towards left end of stomach.	Successful extraction.		Rapid recovery.	Florian Mathis. Recorded by Crollius. Quoted by Sédillot, p. 461.
4				Knife, ten inches long, swallowed six weeks previously. The knife first stuck in the œsophagus, but was forced or washed down into the stomach.	Incision in left hypochondrium. The stomach was hooked forward, and the knife, which could be felt, cut down upon and extracted.	Edges brought together by sutures, and the wound covered up. Restricted diet, vulnerary drinks and balsams; anodyne and emollient injections.	Very rapid recovery.	Schwaben. Quoted by Sédillot, p. 462.
5	1819	F.	24	Silver fork swallowed eight months previously. During three months gave no pain; then the position being changed, caused much suffering; rapid wasting of patient. Fork could be felt through the parietes.	Incision through left rectus muscle. The peritoneal surfaces were adherent. Stomach opened, and fork extracted by forceps. No hemorrhage.	Poultices applied. Some little food escaped through the opening, during the first two days, but not afterwards.	Rapid recovery.	Cayroche, "Bull. de la Faculté et de la Sociéte de Médecine," 1819, t. vi., p. 447. Quoted by Sédillot, p. 457.
6	1823	M.		Silver teaspoon, swallowed some months previously. Could be felt as tumor through abdominal wall.	Swelling cut down upon, and something metallic felt; the opening into stomach was enlarged by bistoury, and the spoon extracted.	Wound healed rapidly. The patient confessed that he had stolen the spoon, and swallowed it for purpose of concealment.	Rapid recovery.	Dr. L. . . . Quoted by Sédillot, op. cit., p. 456.
7	1854	M.	32	Bar of lead $10\frac{3}{4}$ inches in length, 9 oz. in weight.	Chloroform given. Opening made into abdomen from second false rib to umbilicus. Stomach containing the bar grasped. Opening made and bar extracted.	Wound closed by sutures; morphia injections.	Rapid recovery.	Dr. Bell, Iowa. "Boston Journal," vol. lxi., p. 489. Quoted in "Med. Times and Gaz.," 1860, p. 332.

It is doubtful whether life was prolonged by the operation in any of the cases of gastrotomy performed on account of disease; but in several the most manifest comfort and relief were obtained.

In every case, so far as I may venture to express an opinion, and notably in the case under my own care, the operation was performed too late, and the powers of the patient were too far exhausted, to afford a fair chance of success.[1]

The experience hitherto acquired serves, however, to show that the stomach can be reached, opened, and attached to the abdominal walls without difficulty, and that the operation itself is not attended by any immediate danger. Further experience, obtained under more favorable conditions, may not improbably prove more encouraging. It cannot be regarded otherwise than as an opprobrium of surgery, that hopeless starvation should be accepted as the inevitable issue of simple constriction of the gullet.

[1] See paper by the writer in Guy's Hospital Reports, 3d Series, vol. xiv., p. 195.

[Note to the 2d English edition.] In preparing the preceding pages free use has been made of the original article by the late Mr. Henry Gray, the general arrangement of which has been preserved. But the whole article has been rewritten, and very many and copious additions have been made.

INJURIES OF THE CHEST.

By Alfred Poland, Esq.

Revised by John T. Hodgen, M.D., LL.D.

From time immemorial these injuries have been described under two distinct heads, viz., those affecting the parietes, and those involving the contents, the pleura constituting the limit. Although the distinction is merely artificial, still, for practical purposes, we may adopt it on the present occasion. But before proceeding with our inquiries, let us invite the serious attention of the surgeon to the very great importance of an accurate knowledge of the anatomy of the parietes of the chest, and the organs contained therein; for no one can possibly undertake to make any satisfactory diagnosis or prognosis unless he be well acquainted with the fabric of the walls, and with the relative position and adaptation of the contents, as also with the varied phenomena of inspiration and expiration—not forgetting the actual position of the diaphragm and its extensive encroachment within the domains of the chest, carrying along with it, as it does, many of the important abdominal viscera, such as the liver, stomach, etc., which lie under its expanded and protective walls. Moreover, the surgeon should be thoroughly able to appreciate and detect all normal sounds of the lungs emitted through the parietes, by the aid of percussion and auscultation, as well as the natural sounds of the heart and its valves; for without this knowledge he could not possibly undertake to interpret the abnormal signs and sounds consequent upon disease and injury, such as the crepitation of fracture and that of pneumonia—the dulness on percussion, and absence of respiratory murmur in effusions into the pleura and pericardium—the rubbing sounds of pleurisy and pericarditis, etc.

The arrangement of our subject will be as follows: firstly, wounds and injuries of the surface and parietes of the chest, usually denominated non-penetrating wounds; and this section will include fracture of the ribs, and contusion; secondly, wounds and injuries of the interior and the contents, called penetrating wounds; and to this section will be added the rare com-

plication of injured viscera from contusion, unaccompanied by external breach of surface.

I. Injuries and Wounds of the Parietes.

In considering these lesions, we must bear in mind that the wall of the chest is built up of twelve pairs of more or less movable, semicircular hoops of bone, the ribs, which are attached to the spine behind by strong inextensible ligaments, and in front connected by means of elastic solid substances, the costal cartilages, to a central shield of spongy bone, the sternum;—that these cartilages often become ossified, in advanced age;—that between the ribs there are spaces filled up by muscles; and that there is an artery, vein, and nerve, running close along and under cover of the lower border of each rib, in the upper part of each intercostal space;—that the chest is further protected on its surface by the large and powerful muscles which attach the upper extremity to the trunk;—and lastly, that, from its exposed position, additional security is obtained by the scapulæ and vertebral column behind, by the protective position of the arms depending on either side, by the clavicle, and by the almost instinctive movements of the upper extremity in warding off injury in front.

Contusions of the surface of the chest may be of a simple, uncomplicated character resembling the ordinary forms of contusion, which have been already described in the preceding part of this volume; but they may also be attended with lesions to structures peculiar to this region, and these will require special notice. Thus, contusions may be complicated with rupture of the superficial and thoracic vessels, which are of considerable size, and pour out blood freely. This effusion of blood may be confined merely to a certain space; but at other times it may be so very extensive, and so rapid, as to excite alarm lest the main trunk has given way. When seen several days after the injury, it is liable to be mistaken for acute suppuration; but the diagnosis will be based upon the sudden and rapid appearance of the swelling after the receipt of the blow, the soft and fluctuating condition of the enlargement, the absence of discoloration of the skin in the first instance, and the absence of any inflammatory action afterwards. Sometimes the effusion may continue so as to cause tension by over-accumulation, but, generally speaking, these cases are by no means serious, provided they be not meddled with; and there are many instances recorded where the whole of the front of the chest on one side has been bathed in an extensive effusion of blood, and which have yet done well, without causing any bad results. The treatment, therefore, will consist in endeavoring, firstly, to arrest any further effusion of blood, thus favoring coagulation, by cold applications and the use of evaporating and saturnine lotions; and, secondly, to promote the absorption of the extravasated blood, when nature's efforts are sluggish and tedious, by the application of stimulating embrocations, care being taken not to carry this to so great an extent as to excite inflammation.

Sometimes contusions are complicated with rupture of some fibres of powerful muscles, such as the pectoral; these accidents, however, are not very frequently met with in civil practice, but are by no means uncommon in military experience from spent balls, etc. Rupture of a muscle has been likewise observed in cases where the individual has fallen across a projecting body, or whilst falling from a height has grasped a fixed body during his descent. The accident is at once recognized by the total or partial loss of the use of the muscle thus injured, and by the sensible gap existing between the torn fibres. The treatment consists in the relaxation of the muscle and careful approximation of the ruptured ends by position; and this is to be maintained, if necessary, by means of bandages.

Contusions complicated with *fracture of the ribs*, are injuries of very frequent, almost daily, occurrence, and this must be the case when they form one-ninth or one-tenth part of all fractures; thus, of 2275 fractures admitted into Guy's Hospital during a given period, there were 222 fractures of the ribs, exclusive of a large number of other cases of such injury, treated as out-patients; and of 2358 fractures admitted into the Hôtel Dieu at Paris, there were 263 fractures of the ribs. Both sexes are liable, but not equally so, for females are less exposed to injury and accident; thus, of 161 observations at Guy's, 25 were females, being a little more than a sixth; and of 263 observations at the Hôtel Dieu, 48 only were females, being nearly a fifth. With regard to the age, the accident is found rarely to occur in the young, in consequence of the great elasticity of the structures; it is more frequently met with in elderly people, when the ribs have become more firm and the costal cartilages more dense, rendering them less capable of resisting shock, in consequence of some loss of elasticity. Of 161 cases admitted into Guy's Hospital, 9 were under 15 years of age, the youngest being but 2 years old; 26 between the ages of 15 and 30, 78 between 30 and 50 years, and 48 above 50 years old, of whom upwards of 4 were over 70;—thus, under 30 years of age there were 35 cases, and over 30 and upwards no less than 126 cases.

The causes must for the most part be re-

ferred to external injury, such as blows, falls, the passage of wheels over the chest, pressure between two opposing forces, etc.; but in some very rare instances the ribs have been proved to be fractured from internal causes, viz., during the severe efforts of coughing. In these latter instances, the ribs have generally been found in some morbid condition; and Malgaigne has collected 8 such cases, 4 of which occurred in males and 4 in females; their ages were noticed in 6 cases—5 from the age of 47 to 63, and 1 in a young man—the ribs had given way at the anterior part, near the cartilages. M. Malgaigne remarks, that probably the ribs had undergone atrophic thinning, and that the fractures were the result of muscular efforts.

Respecting the condition of the fracture, the ribs may be broken in one of two ways: either at the seat of injury, by a forcible blow or fall on some projecting body, constituting what are termed direct fractures, and in such cases one or two ribs only are found involved, with the broken ends often driven inwards; or, secondly, the fracture may take place at some distance from the site of the external violence, hence called indirect fractures; here the ribs generally give way about their middle, or most convex part, at the point intermediate between the two opposing forces, as for instances in those cases where the chest is squeezed against a wall or a post, or where the wheel of a cart or vehicle passes over the chest: in such fractures, three or more ribs are involved, and the fractured ends are often driven outwards.

Again, the fracture may be incomplete; that is to say, the ribs are only fissured, or, the periosteum being probably preserved and remaining untorn, no displacement or evidence of the existence of fracture is found. Complete fracture is where the rib has been broken through, either in a vertical or oblique direction, and the two ends readily grate against each other during forced respiration. In general there is no shortening, as met with in fractures in other parts of the body, and this is readily explained by the fact of the ribs being firmly fixed both in front and behind; and again there is little or no vertical displacement, because the intercostal muscles are so placed above and below the injury as to prevent any separation in this direction.

Fractures are generally confined to one side of the chest, but in severe and complicated accidents both sides may be involved; in such cases the injury must always be regarded as of the most serious nature. Sometimes a rib may be broken in two places, or even be comminuted; these cases, are, however, rare.

The middle ribs are the most frequently injured, and least of all the first, second, and third;—thus, of 61 cases recorded at Guy's Hospital during a specified time, there were 44 cases involving the fourth, fifth, sixth, seventh, and eighth ribs, 13 cases with fracture of the last four ribs, and 4 cases in which the first three ribs were injured; the fracture of a single rib was observed in 9 of the cases.

Fracture of the ribs may be uncomplicated or complicated. By the former is meant such fracture as occurs without any external or internal lesion; a mere broken bone without injury to adjacent soft structures. Complicated fractures comprise, firstly, those coexisting with an external wound, analogous to compound fracture of the limbs; secondly, comminuted fractures where the rib or ribs have been broken into small pieces, as observed in gunshot wounds; thirdly, where the broken rib has pierced the pleura, causing pleurisy, etc.; fourthly, where it has penetrated the tissue of the lung, inducing emphysema, hemorrhage, pneumonia, etc.; fifthly, where it has injured the pericardium and heart; sixthly, where it has wounded the intercostal vessels; and seventhly, where it has involved the diaphragm and abdominal viscera. All these complications will be referred to under the title of the special injury, such as wounds of the lung, emphysema, etc. The relative proportion of uncomplicated and complicated fractures may be well exemplified by the analysis of 136 cases admitted into Guy's Hospital during five years: 108 were uncomplicated fractures, of which 8 only had secondary inflammation, which proved fatal in 2 instances from previous old-standing disease; 28 were complicated, 16 with emphysema, of whom 4 had symptoms of pneumonia, but all recovered, and of the remaining 12, 6 died at once from fatal collapse, and 6 recovered; of these latter 3 had hæmoptysis and emphysema, and 3 extensive injury and severe inflammatory symptoms.[1]

The ordinary symptoms and diagnosis of a fractured rib *per se* will consist of, firstly, the sensation expressed by the patient of his having felt something snap or give way: secondly, his complaining of pain at the seat of injury, a kind of severe stitch in the side, or catching of the breath during an irregular respiration, while he carefully avoids to take a deep inspiration or a prolonged expiration; even the slightest attempt to cough distresses the patient and disturbs the fracture, giving rise to the sensation of grating: thirdly, the partial arrest of the movements of the ribs on the affected side, as well as of those on the sound side, in consequence of their consonance of action; hence the respiration is

[1] Guy's Hospital Reports, vol. vi., 1860.

carried on principally by the diaphragm and abdominal muscles: fourthly, the detection of crepitus, owing to the movements of the fractured ends one against the other; and this is to be ascertained by manipulative measures, either by simply placing one hand firmly over the seat of mischief, whilst the other hand is employed in making counter-pressure on the opposite side of the chest, and then instructing the patient to take a full inspiration; or by applying the hands one on either side of the supposed seat of fracture and making alternate pressure, so as to cause the two ends to rub against each other; or in very thin subjects, by taking hold of the rib in front and making the necessary movements; or lastly, should all these means fail, by having recourse to auscultation, which will often assist in detecting the crepitation of fracture, notwithstanding the depreciation of its value in obscure cases by some surgeons of excellent authority. It must be borne in mind, that, although crepitus is an essential indication of fracture, yet in some rare instances it may escape detection, and more especially when one bone only is broken, and at a part where it is thickly covered by muscles or much fat, or where the periosteum has remained untorn: hence caution must be used in denying the existence of fracture in consequence of the absence of crepitus.

The prognosis is in general exceedingly favorable, but of course it will be modified according to the primary and secondary complications, more especially the lesion of important structures. In old and elderly persons, who happen at the time to be the subjects of bronchitis, asthma, or other form of chronic disease, a guarded prognosis must always be given, even should the fracture be uncomplicated; for these individuals often succumb, in the one instance, to shock from their low state of vitality, and in the other to a kind of asphyxia from inability to free the lungs of the accumulated mucous secretion.

Consolidation of the fractured ends generally takes place in from twenty-five to thirty days. The callus is thrown uniformly out over the whole circumference of both bones, and seldom or ever forms any great projection on the pleural aspect. Sometimes an excess of callus may extend so far as to form junctions with the rib above and below.

A false joint may arise from deficiency of callus, or from a clot of blood placed between the two ends; but this is not a usual occurrence. Again, callus may be thrown out around each end of the broken rib, and yet the ends themselves not coalesce; this is seen in Prep. 421, in the Museum of the College of Surgeons of England, described thus: "Part of a first rib, labeled in the

Fig. 159.

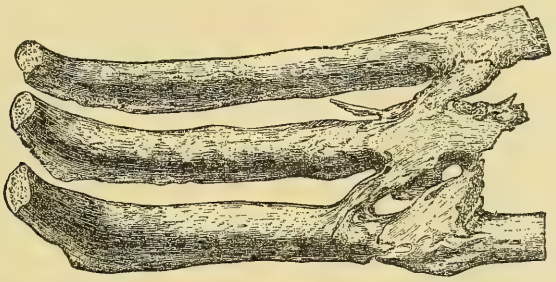


FIG. 159. External view of a preparation of fractured ribs, repaired and united to each other by extension of callus.

Fig. 160.

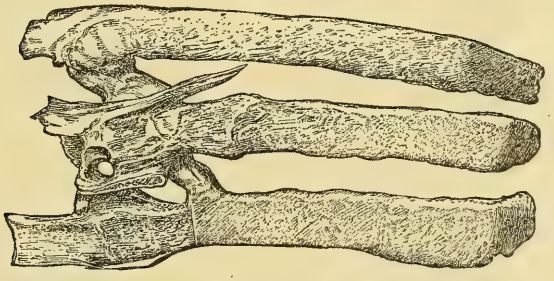


FIG. 160. Internal view of the same. Guy's Hospital Museum.

handwriting of Mr. Hunter. The extravasated blood has dried and absorbed. The adhesive inflammation in the surrounding parts is forming the union. The broken ends of the rib are in apposition, and an irregular ring of new bone is formed round each of them; but the two rings have not coalesced so as to form a bond of union like a provisional callus encircling the fractured part; neither has any union taken place between the bones themselves." See also the remarks and figures in the essay on FRACTURES, p. 499.

In the Museum of Guy's Hospital is a very interesting and remarkable skeleton of a rhinoceros, in which almost every rib on either side has been fractured and repaired. It shows in a marked manner the beautiful arrangement of the disposition of the callus. Some of the ribs had been fractured in two places, and it would appear that the animal had been at various times struck with an iron bar by his keeper. The carcase was bought of the proprietors of the Surrey Zoological Gardens many years ago, when the animal had died.

The treatment comprises local and constitutional measures. The local treatment consists in maintaining the ribs in as perfect a state of rest as possible, and this is to be accomplished by rendering them immovable, by any of the following plans: firstly, and this is by far the most preferable, the application of long strips of adhesive plaster, extending from the spine to the sternum of the affected side, and successively applied to some distance both above and below. These possess the advantage not only of not being easily displaced, but of affording a more effectual relief by confining and restraining that side of the chest without affecting or interfering with the free action of the opposite side in the acts of respiration. Some surgeons prefer the use of a large sheet of strapping, instead of the long strips, but its application is not so uniform or so satisfactory. Secondly, the use of a flannel roller, about one hand's breadth wide and eight to ten yards long, which is made to encircle the chest by several turns and with a moderate degree of tightness. The roller is, however, liable to slip, and requires reapplication every second or third day. Some use a broad sheet of linen, which is passed around the chest and fixed either by pins or needle and thread, and there maintained in this position by a kind of braces carried over the shoulders, similar to the double T bandage of the French; others again prefer a simple belt and scapulary, which is merely a mechanical adaptation of this latter. Thirdly, the use of compresses, pieces of pasteboard, splints, etc., which are sometimes required, more especially in those cases where the fractured ends are driven inwards; and the object of the surgeon being to lever out the displaced bones, or at all events to prevent the ends from making further pressure on the internal structures, these splints or compresses are placed vertically on either side of the fracture at some little distance, and maintained there by strapping, when the whole is inclosed by encircling the chest by several turns of a broad flannel or linen roller. Fourthly, the recumbent position in bed has been recommended, and even adopted by some surgeons, instead of local treatment, and without any application whatever; but this plan is rarely adopted, except in those cases where the least pressure or confinement of the chest gives pain and uneasiness. This is the exception rather than the rule, for in the majority of cases the confinement of the movements of the ribs is described as being grateful, giving great relief, and allowing a gentle, easy, and comfortable respiration. [While the value of dressings that restrain the movements of the ribs in respiration cannot be denied, it is nevertheless true that the patient soon becomes capable of restraining those movements that give pain, and when this occurs dressings are no longer required.]

The constitutional treatment will comprise the administration of the ordinary remedies, according to the general principles of surgery; such as rest and quietude for several days, a careful and judicious diet, and abstinence from stimulating drinks. Where much cough and bronchial irritation supervene, expectorants, diaphoretics, and demulcents, may be usefully employed. Where there is much dyspnœa, the exhibition of antimony and antiphlogistics is highly important; the antimonial wine being the most effective medicine, to be administered in frequent doses, and varied in quantity, according to the age and powers of the patient. Where there is hæmoptysis or subsequent pleurisy or pneumonia, in addition to these remedies venesection must be had recourse to; but this powerful agent must be judiciously and cautiously wielded. In properly selected cases it acts as a charm, and often snatches the sufferer from impending death; its chief indications are, the continued and distressing dyspnœa, the oppressed circulation, as evidenced by the laboring pulse, and the strength and powers of the individual. In former years it was too much the fashion to employ the lancet in cases of fractured ribs; but latterly the current of practice has rather flowed towards the opposite extreme, perhaps too much so; however, the surgeon must be entirely guided by circumstances, and meet the difficulties and complications as they arise, by adopting prompt measures, recollecting that the young bear active treatment better than old people. Of the 136

cases already alluded to, as admitted into Guy's Hospital, the majority of the cases, viz., 100, required little or no constitutional treatment, and of the remainder only three required venesection. In appropriate cases of internal inflammation, mercury is invaluable.

Fractures of the sterno-costal cartilages, uncomplicated with other injuries, are exceedingly rare, although recorded as early as the year 1698, by Zwinger, who found this injury when examining a dead body, and in 1805 by Lobstein. Majendie has written a thesis on the subject, wherein he states, that he had seen upwards of five examples in the space of two years. Malgaigne, in his work on fractures, writes, that he had only seen three cases; and that at the Hôtel Dieu, there was only one case in 2,328 cases of fracture generally. He attributes this paucity to the probable omission of this lesion in the hospital returns. The causes of this injury may be, like those of the ribs, direct or indirect. The eighth rib is said to be the one most

Fig. 161.

Fig. 161. Fracture of the first bone of the sternum transversely; from a man aged fifty-six, who fell forty feet from a scaffold and died in two and a half hours. He had likewise fractured spine, ribs, and other bones.
(*From preparations in Guy's Hospital Museum.*)

liable, then those immediately above it: generally speaking, one end overlaps the other, which renders the diagnosis easy, and these ends may become united in that displaced condition by osseous matter without any subsequent ill effects. Delpech remarks: "If the fracture takes place near the sternum the internal fragment passes in front and crosses the external; the contrary when the fracture is nearest the rib." Fracture of the cartilage becomes repaired by bony union, ossifying callus; but not always so. In the Museum of St. Bartholomew's Hospital are three specimens: Series iii., No. 4, section of a cartilage of a rib which appears to have been fractured and reunited by the growth of a new cartilaginous substance; No. 48, section of the cartilage of a rib which has been fractured and is firmly united; the uniting medium consists of cartilage and of bone; and No. 73, where the fractured portions are surrounded by a ring of bone.

Fig. 162.

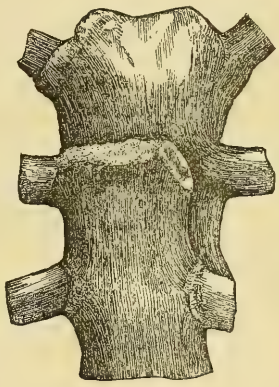


Fig. 162. Fracture of the second bone of the sternum transversely and obliquely; from a man aged forty, who fell off a wagon-load of hay, and was sent up to the hospital from the country, and died on the following day.
(*From preparations in Guy's Hospital Museum.*)

The treatment will be the same as for fractured ribs: some, however, have recommended that, where one end overlaps the other, pressure should be made, so as to restore them to position; but inasmuch as great force must necessarily be used, which may cause injury to the soft parts, and the risk of inducing sloughing of the integuments, this plan is generally deprecated. Malgaigne states that he has used with success a modification of the common truss, furnished with well-protected pads: the one pad is placed on one side of the fracture, the semicircular spring made to encircle the chest, and the counter-pad made to press upon the other end of the fracture. By this means in one case, after twenty days' application, he found the fractured ends *in situ*, and a perfect cure resulted.

Fracture of the sternum is also by no means common, for during eleven years at the Hôtel-Dieu only one example is re-

corded; and at the Middlesex Hospital, according to Mr. Lonsdale, two cases were met with in 1,901 fractures. At Guy's Hospital, during five years, two cases occurred, one of which was not detected during life, but was associated with other more severe injuries; one case only was admitted in the year 1843, another in 1845, and another in 1846. It is probable, however, that the rarity of this injury has been exaggerated. Fracture of the sternum alone is, indeed, an extremely uncommon accident; but as a complication of fractures of the spine or ribs, it is much more frequently met with: thus, at St. George's Hospital, during the four years 1857–1860 inclusive, nine cases of fractured sternum were dissected; of these, three were associated with fractured spine, and six with fractured ribs.

These fractures may be either transverse or longitudinal; the transverse are the most common, but are by no means always transverse, in the strict sense of the term; the causes are generally direct external injuries. The fracture is often associated with other severe lesions, such as fractured spine, ribs, skull, etc.; or it may be produced by indirect violence, by the forcible bending of the body backwards in falling across a projecting body, thus snapping the bone or tearing asunder the first and second pieces of the sternum; such cases are quoted by Sabatier,[1] Rollande,[2] and Malgaigne.[3] Sometimes the contrary condition will cause it, viz., the forcible flexure of the trunk forwards, and the simultaneous occurrence of a contre-coup, by falling either on the feet or the head. [I have met with four cases of fracture of the sternum occurring in connection with fracture of the spine, and all due to violently bending the body forward. In one case the patient was seated on a wagon which was driven under a beam. He leaned forward to allow his head to pass the beam, which caught his shoulders, and as the hips were carried under the beam, the dorsal spine and the sternum were broken. He recovered.

In a second, the patient fell backward from a cart, striking on the shoulders. The trunk bent forward, breaking the spine and sternum. He died.

A third stumbled when near a hatchway, fell through to the floor below, alighting on the shoulders, breaking the spine and the sternum. Recovered.

A fourth fell ten feet from an outside stairway, alighting on the buttocks, and breaking the spine and sternum. This patient was treated with a plaster of Paris jacket, was on his feet every day, and recovered. In the fourth case the fracture of the sternum was first detected, and this led to an inspection of the spine, of which there had been little complaint.] Sometimes, but rarely, it has followed excessive muscular action: Chaussier relates two examples of the kind; both patients were females, of the ages of 24 and 25, and the fracture occurred during the efforts of labor with a first child; at the time of parturition both patients threw back their heads, and rested at times on their arms and heels, bowing up their bodies; there was only slight displacement of the fracture in the one case, and none in the other. This accident was observed by Dr. Faget of Mexico: it happened to a celebrated vaulter, who, whilst bending his body backwards, was endeavoring to raise a heavy weight with his teeth.[1]

The symptoms are the following: the sensation of a breaking or cracking at the time of the accident; pain at the seat of injury, aggravated by deep inspiration or by coughing; the detection of the fracture by manipulation, or else by the overlapping of the bones, if displaced. Sometimes there is no displacement, owing to the fibrous and fascial investment remaining intact; but generally the bones ride over each other, and, in nearly all the recorded cases, it is the inferior fragment which lies in front, and is the most fixed portion; notwithstanding its movement during respiration, being pushed forwards in inspiration, and backwards in expiration, the displacement causes no inconvenience.

The diagnosis is generally easy, except where there is much swelling and effusion.

The prognosis is favorable where there is no complication nor other severe injury.

The treatment will be the same as for fractured ribs; sometimes the bandage or strapping cannot be borne, so that the patient must be kept in the recumbent position; sometimes, though rarely, he cannot even bear this, and is only comfortable when in the sitting position, with an inclination of the body forwards, resting the head in front; and in this state some have actually remained for eight days. Where the bones have been much displaced, efforts have been made by some surgeons to reduce the fracture, by placing a cushion under the chest, and throwing the shoulders well back, and pressing, at the same time, on the ribs below, thus causing an increase of the arch, and so bringing the edges of the bones into apposition: many other plans have been

[1] Sabatier, Memoir on Fracture of the Sternum, read at the Institut de France, le 26 Germinal, An VI.

[2] Bulletin de Thérapie, tom. vi.

[3] See also Gürlt, Handb. d. Lehrev. d. Knochenbrüchen, 2ter Th., p. 264 et seq., especially p. 311—"Uebersicht über die Casuistik—105 Fälle."

[1] A similar case is referred to by Gürlt, where the patient recovered.

devised for the same object, but in general, although the reduction may be perhaps readily effected, the difficulty consists in retaining the ends *in situ*. Respecting the suggestions for the use of a kind of corkscrew, to be screwed into the depressed portion, so as to draw it up, and for the employment of elevators and trepans, all these must be considered as not only useless, but the relics of the old cruel and barbarous surgery.

Longitudinal fractures of the sternum are very rare, so that their occurrence has been denied by many authors.

Two cases are mentioned by Plouquet,[1] and one by Barrau.[2] The latter case is quoted by Malgaigne, as follows: a mason, aged 60, fell from a scaffold on some large stones; the fracture was longitudinal, and the right portion depressed about eight to ten lines, the left somewhat overlapping: reduction was effected by drawing the arm to the side, and carrying it backwards, then pressing firmly on the middle of the right sternal ribs, making alternate movements from before backwards, so as to disengage the bones, whilst at the same time, gentle pressure was made on the left or riding portion, so as to keep it on its own level. After reduction, a compress was applied, and maintained by a firm bandage: the case was successful at the end of six weeks, and no deformity resulted.

Fracture of the sternum may be complicated with other injuries, as has already been partly alluded to. The most ordinary complication of this fracture is its occurrence in cases of fractured spine; but sometimes it may cause injury and inflammation of the pericardium, pleura, lungs, mediastinum, heart, etc. These complications will be alluded to in considering the injuries of those structures.

Dislocations of the ribs.—1. *Costo-vertebral.*—The anatomical arrangements for this important articulation would tend to prove that it would be almost impossible to luxate the head of the rib without fracture of the neighboring parts, so strong are the ligamentous tissues around. Yet it does appear notwithstanding that luxation has been effected after severe violence. However, in most instances, other complications have existed, generally fracture of the spine and displaced vertebræ. Platner observed that fracture rather than dislocation usually took place, and that the head of the rib could be only dislocated inwards, not easily upwards or downwards, and never outwards, in consequence of the transverse process. Boudet arrived at the same conclusion, as detailed in a memoir on the subject presented to the Académie de Chirurgie; the case of dislocation alluded to by him, however, was clearly proved by Boyer (Mal. Chir., t. x., p. 123) to have been one of fracture of the rib near the spine.

Such cases are too few to make it necessary for me to offer many remarks upon the accident. The causes must necessarily be direct violence over a small amount of surface, so that it is expended upon one or two ribs, thus driving the heads forwards and inwards; the force may also be thrown upon the angle of the rib. The opposing forces must be powerful. The diagnosis is difficult, and must be only conjectural: thus there may be a deep depression, but this does not appear to be always present; and it may be overlooked, for there is great ecchymosis and swelling, with pain; there may be mobility of the rib without crepitation.

Table A, page 755, will elucidate the subject more fully.

The dislocation is generally discovered after death. In two of Kennedy's cases, Nos. 6 and 7, the patients recovered; in the boy, No. 7, the diagnosis was purely conjectural, and may be questioned altogether; and considerable doubts may be raised respecting the other case. However, taking into account the case of Sir A. Cooper, which was distinctly verified some years after, we may fairly accept Dr. Kennedy's case as one of dislocation.

2. *Costo-chondral dislocation* (Table B, page 757) is evidenced by the prominence of the rib in front of its corresponding cartilage. It is a question whether these are not cases of fracture. They are not of much importance, and require the same treatment, reduction and its maintenance, as for fractures.

3. *Chondro-sternal dislocation* (Table C, page 758).—Demarquay remarks that in the four cases there reported, it seemed to be rather a sinking in of the sternum, which had caused the luxation.

This luxation is accompanied with prominence of the cartilage and pain, and may be attended with severe after-symptoms, febrile excitement, and spitting of blood.

4. *Dislocation of cartilages upon each other* (Tables D, E, page 759).—It is a question whether these cases were not fractures. The sixth, seventh, and eighth ordinarily articulate with each other; sometimes the fifth and sixth, as also the eighth and ninth at times.

5. *Dislocation of the bones of the sternum*: the first piece dislocated from the second piece (Table F, page 760). Malgaigne divides these into traumatic and idiopathic luxations. Of the *traumatic* variety, he gives ten cases, all males, and occurring between the ages of eighteen and sixty. The causes were either direct or indirect; the direct causes were the rarest: the sternum receiving a violent blow, and great pressure

[1] The two cases of Plouquet are those of Krämer and Mayer.

[2] Barrau, Thèse de Strasbourg, 5 janvier, 1815.

being exercised at the time on the first piece, forced this backwards behind the lower portion; the indirect causes were variable—falls from considerable heights, bending of the spine forcibly forwards, so that the two pieces being pressed together, the lower becomes displaced in front of the upper. These rare dislocations are generally due to extreme violence, and associated with other severe injuries. The symptoms of the recorded cases were, local pain, difficult respiration, separation of the pieces, and prominence of the second portion. Of the ten cases five terminated fatally, owing to the complications.

During the past thirty years, at Guy's Hospital, several cases of dislocation of this bone have been witnessed; reduction could not be accomplished. Where the lesion was uncomplicated with other injuries, the patient generally recovered without any other inconvenience than the deformity.[1]

[In the Am. Journal of the Med. Sciences for July, 1867, there may be found an exhaustive article on this subject, from the pen of Dr. Brinton of Philadelphia.]

Of the pathological variety, Malgaigne gives three cases only. They possess some degree of interest, and are recorded in his work on dislocations.

The tables on the following pages give a short reference to the recorded cases of these several dislocations.

Contusions of the parietes are sometimes followed by inflammation, suppuration, and the development of tumors; these subjects are treated of elsewhere. In the female the mamma is peculiarly liable to injury, a subject which will be referred to under the head DISEASES OF THE BREAST. There is one complication, however, which requires special mention in this place; it is that of subpectoral abscess, or diffused suppuration under the pectoral muscles, which is generally the consequence of injury. It is attended with severe constitutional symptoms, but the local signs are very obscure, and give no definite indication of its existence; there is great pain, and general tumefaction in the pectoral region, and no evidence of fluctuation, unless the pus reaches the axilla, when its presence may be detected. Its diagnosis must mainly be based upon the constitutional symptoms, viz., severe constitutional irritation, with febrile disturbance, and unmistakable rigors; these, with marked tumefaction, fully warrant the surgeon in making an exploratory incision through the pectoral muscles, in the direction of their fibres, so as to give an exit to the pus. In the course of ten years the author had occasion to perform this operation on four several occasions, and with satisfactory results. After the matter is evacuated, it is essential to keep the wound open, by the introduction of a tent, or else the muscular fibres will close the opening, and a reaccumulation ensue. The tent is to be replaced once or twice daily, as occasion may require. Tonics and good diet must be administered.

Periostitis, necrosis, and caries of the ribs and sternum, do not require special notice, and the operation of resection of the ribs is described in the essay on EXCISIONS.

[1] Maisonneuve, in the Archives générales de Médecine, 1844, sér. 3, vol. xiv., p. 225, has written a most excellent and elaborate memoir on dislocation of the sternum, which is worthy of perusal by those interested in these forms of injury.

TABLE A.—COSTO-VERTEBRAL DISLOCATION.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Post-mortem Examination.	Reference.
1	M.	Young.	Fell into a pit of clay.	Tumor of size of fist over twelfth dorsal spine. Paralysis of lower extremities.	Died fifteenth day.	Fracture of eleventh vertebra, and of twelfth rib on each side. Luxation of left eleventh rib.	Henkel, "Gaz. Méd.," 1834, p. 137.
2	M.	32	Fell ninety feet.	Immediate death.	Died.	Fourth left rib thrown forwards and inwards. Laceration of pleura and lung; no fracture of rib, but fracture of corresponding transverse process.	Boudet, "Bull. de la Soc. Anat.," 1829, p. 104.
3	M.		Part of a roof fell upon his back.	Fracture of spinous process of sixth and seventh dorsal vertebræ. Paralysis and other symptoms of spinal injury.	Died fifteenth day.	Fracture of sixth dorsal vertebra, and sixth, seventh, and eighth ribs on both sides. Two had their heads dislocated.	Alcock, "Lond. Med. Gaz.," 1839, p. 587.
4	M.	11	Blow from heavy lump of turf.	Tumor over heads of two or three last ribs. Paralysis and retention of urine. Suppuration ensued around seat of injury.	Died sixth day.	Complete dislocation of tenth rib forwards; and partial dislocation of the eleventh rib.	Kennedy, "Dub. Med. Press," 1841, vol. v., p. 30.
5	F.	15	Beams from roof of cottage fell upon her, one resting on her back.	Immediate death.	Died.	Dislocation of two last ribs on left side. Fractured skull, etc.	Kennedy, "Cooper's Dictionary," vol. i., p. 514.

COSTO-VERTEBRAL DISLOCATION.—*Continued.*

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Post-mortem Examination.	Reference.
6	M.	20	Fall through scaffold, a portion falling on him.	Supposed dislocation of two last ribs on left side, downwards and forwards. Stated to have come back to natural position in three weeks.	Uncertain.		Kennedy, "Dub. Med. Press," 1841, vol. v., p. 30.
7	M.	17	Fall from top of high tree, striking back on one of projecting roots.	Indentation over two last ribs of right side. He rapidly recovered, and in ten days no depression was felt.	Uncertain.		Kennedy, "Dub. Med. Press," 1841, vol. v., p. 30.
8	M.		Several years before, was thrown off a horse across a gate, and was treated as for fractured ribs.	Lived some years, and died of fever.		Head of seventh rib thrown upon front part of corresponding vertebra, and there anchylosed.	Cooper, "Dislocations, etc.," edited by B. B. Cooper, p. 521.
9	M.	44	Fell from a third story, and lived five minutes after admission into hospital.		Died.	Left seventh rib completely dislocated forwards on to the vertebra without fracture. Fractured eighth, ninth, and tenth ribs, with injury to the lungs and diaphragm. Fractured lumbar vertebra. Fractured sternum, and other injuries.	"Post-mortem Records, Guy's Hospital," 1864, No. 178, Mr. Birkett.

Table B.—Costo-Chondral Dislocation.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, etc.	Reference.
1	M.	48	Attacked with fits of severe coughing.	Luxation of eighth rib, on left side, and of seventh rib on right. Accompanied with hernia of lung between eighth and ninth left ribs, and seventh and eighth right ribs.			Chaussier, "Bull. de la Faculté," 1814, p. 50.
2	M.		Thrown from donkey; the animal stepped on his chest—right side.	Separation of fourth rib, displaced backwards and downwards. Became replaced on deep inspiration.	C.	Bandage applied during inspiration, and perfect cure resulted.	Bouisson, "Cooper's Dictionary."
3	M.		Thrown from horse, striking chest against corner of mile-stone.	Luxation of fifth left rib, which was driven inwards.	C.	Replaced readily by strong dilatation of chest. Bandages. Recovery.	De Kimpe, "Annales de la Chir.," t. ix., p. 316.
4			Pressed between a post and a carriage.	The majority of the ribs luxated upon their cartilages.			Charles Bell, "Surg. Obs.," p. 171.

TABLE C.—CHONDRO-STERNAL DISLOCATION.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, etc.	Reference.
1	M.	Young.	Exercising with dumb-bells—violent extension of arms.	Felt something give way suddenly; one of the costal cartilages found luxated forwards on to the sternum.	C.	Replaced by pressure with fingers, and retained by compress and bandages.	Sir C. Bell.
2	F.	72	Fell down during intoxication.	Luxation of fourth left cartilage.	C.		Ravaton.
3				Cartilages of fourth, fifth, and sixth true ribs luxated in front.	C.	Reduced by pillows behind back, and arching the spine.	Manzotti, 1790.
4				Luxation of a true rib in front of sternum.	Uncertain.		Monteggia.
5	Baker's boy.		Constant action of pectorals in kneading bread, and defective constitution.	Luxation of cartilages of fifth and sixth ribs.	Uncertain.	Advised to desist from employment.	Cooper "On Dislocation," edited by B. B. Cooper, p. 447.

Table D.—Luxation of Cartilages one upon the Other.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, etc.	Reference.
1	M.	70	Fell backward off a chair, and tried to regain his position.	Painful cracking of chest. Swelling over three last true ribs of right side; elevation of ribs so that hand could be passed readily beneath them.			Martin de Bordeaux, "Journ. de Vandermonde," 1780, t. liv., p. 328.
2				Similar case under similar circumstances. Inferior cartilage luxated behind; sixth, seventh, and eighth ribs displaced.			Boyer.
3			Violent effort.	Seventh, eighth, and ninth ribs displaced from their articulation with each other.			Malgaigne, "Traité des Fract.," t. ii., p. 398.

Table E.—Ensiform Cartilage.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, etc.	Reference.
1	M.	18	Cartilage driven in by blow on epigastrium.	Frequent vomiting, continued until reduction was effected.	C.	Reduction by pressing the fingers beneath it, and elevating it into its place.	Martin, "Histoire de l'Acad. des Sciences," 1737, p. 48.
2	M.	19	Fell upon the seat of a boat, and struck his epigastrium.	Violent dyspnœa and vomiting, with pains in stomach; he was for twenty-five days unable to swallow fluids without rejecting. Death imminent.	C.	Incision made on one side of the depressed cartilage, extending through the peritoneum; an instrument passed beneath, and cartilage raised into its place. Immediate relief.	"Journ. Général de Méd.," t. xxii., p. 263, 1804.

TABLE F.—DISLOCATION OF THE BONES OF THE STERNUM.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, etc.	Reference.
1	M.	27	Fell forty feet on to pavement.	Dislocation of first piece behind the body of sternum. Fractured cartilage of third rib. Fractured left clavicle and fourth dorsal vertebra. Paraplegia.	D.	Lived six weeks.	Maisonneuve, "Archiv. Gén. de Méd.," 1842, t. xiv., p. 255.
2	M.	42	Fell forty-two feet on to pavement.	Second piece thrown in front of first. Fractured sacrum, disjunction of left sacro-iliac joint. Fractured vertebræ and ruptured bladder.	D.	Expired in a short time.	Do. Do.
3	M.	48	Fell from height on back.	Second piece in front of first. Fractured fifth cervical vertebra. Paraplegia.	D.	Died on fifth day.	Do. Do. Manoury and Thore's case.
4	M.	Adult.		Luxation of first from second; the latter in front of upper. Fractured left clavicle and scapula.	D.		Do. Do. Musée Dupuytren.
5	M.		Fell from a ladder, one of the bars struck his chest.	Luxation of first and second pieces.	C.	Replaced dislocation by placing a cushion across back and arching the body over it; maintained by bandages for twenty days.	Do. Do. Auran's case.
6	M.	23	Fell into a cavern, and chest compressed by pieces of wood.	Luxation of first and second pieces.			Malgaigne "On Fractures and Dislocations."

7	M.	60	Thrown into ditch, thirty feet, and fell against large stone.	At seat of union of first and second pieces, separation by fracture, and lower portion thrust under the upper.	D.	Lived eight days.	Maisonneuve, quoted from Sabatier.
8	M.	28	Fell fifty feet on to a wall, back being bent across it.	Separation of first and second pieces. Fracture of two last dorsal vertebræ and femur.	C.		Do. Do. Case of Auran and David.
9	M.		Passing from one boat to another, fell and struck upper part of sternum against angular border of boat.	Dislocation of first and second pieces.			Malgaigne, "Case at Hôpit. St. Antoine."
10	M.		Indirect cause: was lying on side when enormous stone fell on chest, compressing it laterally.	Second piece projected in front of first, and with such force as to cause a wound.			Malgaigne, Duverney's case.
11	M.		Fell from first floor. Body flexed forwards.	Dislocation of first and second pieces with fracture of cartilage of left second rib.			Do. Do. Chevaner's case.
12			Muscular action.	Separation, with fracture of sternum, first and second pieces.			Malgaigne.
13	M.	25	Not stated.	Second piece dislocated and thrown forwards on first. Fractured vertebræ.	D.	Lived two weeks, and died from effects of spinal injury.	"Post-mortem Records, Guy's Hosp.," 1827. Prep. Museum, 1043.[30]
14	M.	25	Struck on chest by a projecting part of an express train.	Dislocation of first and second pieces; the two first ribs remained attached to the upper portion. The lower part was thrown in front of the upper.	C.	Placed in a recumbent position with two bolsters under the back, and at the end of three days, bones resumed their natural position. Entire recovery.	Demarquay, "L'Union," 1868, No. 47.

TABLE G.—PATHOLOGICAL LUXATION OF BONES OF STERNUM.

No.	Sex.	Age.	Cause.	Symptoms.	Result.	Treatment, etc.	Reference.
1	M. Student in medicine.	23	Had pain in sternum, causing him to make constant pressure. Osteocopic pains.	Disjunction of the first and second pieces ensued; a false movable joint formed, and subluxation.		Arthritic relaxation of joint—query, venereal? Anti-venereals gave no relief.	Beauchêne, "Journ. Général de Méd.," t. xxxiii., p. 287.
2	M. Mechanic.	Adult.	Employed in early youth at watch-making, and short-sighted; constant bending.	Gradual gliding of first piece in front of second—subluxation.	C.	Readily reduced; could subluxate it voluntarily. Cured by avoiding the bending position.	Malgaigne on "Dislocation," case of Martin.
3	M. Student in medicine.	19		Could push backwards with the hand the body of the sternum and its corresponding ribs to extent of two inches, so as to leave a hollow at anterior part of thorax.		Often had severe inflammation of the chest.	Dr. Graves, of Dublin, "London Med. and Surg. Journ.," 1835, vol. vii., part 2, p. 577.

Wounds of the parietes of the chest, commonly called non-penetrating wounds, include the several varieties of incised, punctured, lacerated, and gun-shot wounds; the general characters of which are described in the essays on WOUNDS and GUN-SHOT WOUNDS. Here we shall merely refer to certain special complications of the ordinary incised, punctured, and lacerated wounds, as they affect the surface and tissues of the chest. In the first place, the surgeon is always anxious to decide whether the wound be superficial or penetrating: are there any signs sufficiently well marked to indicate that the wound has not penetrated the chest? This question will be more appropriately considered when alluding to penetrating wounds, for it will be found that the only reliable signs are those of a negative character, viz., the absence of all the symptoms indicating a penetrating wound.

Wounds involving the skin and cellular tissue of the chest require no comment, otherwise than in the punctured variety; where there may be a long track traversed by the weapon, which may give rise to the formation of sinuses and local abscesses, and be difficult to manage in consequence of the movements of the upper extremity and the acts of respiration.

M. Vidal[1] remarks that punctured wounds, even of the slightest character, may be attended with symptoms simulating those of lesion of some internal organ or internal hemorrhage; such as coldness of the skin, feeble circulation, a sense of suffocation, syncope, and cough. These phenomena, he states, are chiefly observed in wounds received in duels. Whatever may be the courage of the champion, at the moment of combat the blood does not circulate normally, and the innervation is not regular, and he is not without emotion; if to this moral state there is superadded a wound of the chest, the wounded person regards it with most vivid uneasiness, and if fear has not already set in, it will soon take place. Thus is readily explained the occurrence of the above phenomena, and the salutary effect of removing these impressions by moral agencies of a reassuring kind.

Wounds of the muscles in front and behind the chest, when passing across their fibres, are attended with very great separation, and leave a large gap, in consequence of the power and extent of the individual muscle involved. And in the treatment of such wounds, the function of the divided muscle must be borne in mind, so that the edges may be approximated as closely as possible; thus, in wounds of the muscles in front of the chest, the arm must be drawn forwards, and carried inwards towards the opposite, and maintained in this position during the healing of the wound: in wounds of the muscles behind, the opposite course is to be pursued. In a case of extensive wound of the latissimus dorsi muscle, and in a case of wound of the pectoralis major, M. Petit applied several points of suture, and with success; but sutures through muscular tissue are in general not advisable, unless there be a very large flap; and when employed, they should include the fascia in front of and behind the muscle, else the suture will tear away. Transverse wounds of the intercostal muscles weaken the chest, and sometimes permit the escape of the lung, to which we shall refer further on.

Wounds of the thoracic and other parietal vessels (excluding the intercostal and internal mammary) partake of the ordinary characters of wounded vessels: the only peculiarity in respect to the chest is in reference to punctured wounds, as in stabs by a sword, bayonet, foil, etc., where a vessel has been involved, and the blood, not being able to escape externally, has diffused itself under the muscles in the loose cellular tissue, and sometimes to a very great extent. This extravasation may coagulate and further effusion cease, when subsequent absorption ensues, with speedy recovery: on the other hand, it may excite inflammation, suppuration, and sloughing. Ice, or carefully applied compression, will be sufficient to arrest the hemorrhage, if not of very considerable extent; but where one of the larger trunks, such as the vessels of the axilla, has been injured, the case must be treated according to the rules laid down in the essay on WOUNDS OF ARTERIES.

Wounds involving the ribs, costal cartilages, or sternum, require immediate closure of the wound, or the ordinary treatment for fractured ribs. Here, however, we must be on our guard, and ascertain whether or not a portion of the weapon or instrument has been broken off and become imbedded in the rib, or cartilage; an event which has happened once or twice. In general the piece is loose, and readily removed, but in some instances it has been found fixed, requiring immense force to extract it; or it may be smooth and convex on its surface, such as a bullet, when difficulty is experienced in laying hold of it. Sometimes the pointed instrument may traverse the rib and appear on its inner side, causing a penetrating wound of the chest; this we shall refer to again.

Non-penetrating wounds may be attended with emphysema; thus, in wounds traversing the soft parts obliquely and gliding under the large muscles of the chest into the subjacent loose cellular tissue, the air from without may enter into the wound, being drawn in by the movements of the ribs; and this air, not being able again to

[1] Vidal de Cassis, Traité de Pathologie externe, tom. iv., p. 66.

escape, during expiration becomes diffused, causing emphysema, which may occupy a very extensive surface. A great deal of this air may be pressed out through the wound, but in so doing, care must be taken to close the wound at each inspiration, so as to prevent fresh air being drawn in.

II. Injuries and Wounds of the Contents of the Chest.

These will be treated of under two separate heads: first, those produced by external wounds, commonly called penetrating; and second, those caused by contusion, without any breach of the external surface.

Respecting penetrating wounds, these will be best considered by studying them according to the organ or structure involved, in the following order. 1. Wounds of the pleura and lungs, with their attendant complications; 2. Wounds of the mediastina, pericardium, and heart; 3. Wounds of the intercostal, internal mammary, and large vessels of the chest; 4. Wounds of the œsophagus.

1. *Wounds of the pleura and lung, and their complications.*—In the first place, there may be a simple penetrating wound of the pleura, without injury to any other structure. This accident is exceedingly rare, and to the anatomist might appear scarcely possible, in consequence of the close adaptation of the lung and its pleural covering to the wall of the chest and its pleura; there are, however, sufficient facts proving that this injury does now and then take place, more especially in incised wounds; although its recognition is very difficult. Where the wound is large and the lung distinctly visible, and air is freely drawn in and expelled from the pleural cavity during respiration, the nature of the injury is palpable enough; but these wounds in general are not so extensive, owing to the protection of the ribs; hence we must rely upon other diagnostic marks. And here we are again baffled, because the chief signs are entirely of a negative character, viz., the absence of all the varied indications of a wound of the thoracic contents. The following means have been proposed to assist in the diagnosis: 1st. Deductions drawn from the weapon used, with its attending external circumstances; these will comprise the consideration of the varied forms of penetrating instruments, the extent of the blood-stain upon the blade, the size of the wound compared with the breadth of the blade, the respective positions of the injured person and the aggressor at the time of the infliction of the wound, the mode and direction in which the weapon was thrust, etc. These points are by no means decisive, and are often doubtful; for the blade may have two cutting edges, and then the wound will be larger; the bayonet or sword-thrust may glance off the ribs and pass a long distance under the skin, without entering the chest —thus cases are related in which a sword has passed from the right to the left of the chest without penetrating the cavity; again, the position of the combatants is often inaccurately stated. 2d. Exploration by means of the finger, probe, sound, or other instruments. Were this to be permitted, and a careful and minute examination made by the introduction of the finger into the wound, an easy diagnosis would at once be realized; but in wounds of the chest, as in wounds of the abdomen, all manipulative examination is to be denounced as perfectly unwarrantable, being attended with highly dangerous results, by disturbing nature's efforts to effect a repair, disarranging the clot, and exciting irritation and inflammation; a proceeding tending only to gratify curiosity, without the slightest benefit to the patient. The same remarks apply to the injecting of fluids into the wound, which is to be considered as a relic of barber-surgery, and is wisely expunged from all modern works. 3d. Another mischievous and meddlesome proposition is the following, viz., the closing of the external wound, and then directing the patient to take a deep inspiration, when he is to hold his breath so as to close his glottis; and then to make an effort to expire, at the same time that the surgeon reopens the wound and holds a lighted candle close to it; should the wound have penetrated the lung, air will be driven out through the opening and blow the flame of the candle to one side. This must always be regarded as a dangerous and hazardous experiment; and even if justifiable, it is not conclusive evidence, for in many cases of penetrating wounds of the lungs, there are several circumstances which may prevent the escape of air from the organ. 4th. The absence of emphysema is no indication that the lung has not been wounded; emphysema, although a usual symptom of injured lung, may occur even in non-penetrating wounds, as has been already mentioned; it may also take place in wounds penetrating the pleural cavity only; thus air may be drawn in through the external wound during inspiration, and on expiration this air, not finding a ready exit, may be expelled into the neighboring cellular tissue; or if the incised wound be very large, the air will enter the cavity in a large volume, and should it be unable to escape, it will cause a pneumothorax. 5th. The absence of hæmoptysis is by no means a sufficient test that the pleural cavity only has been penetrated. Hæmoptysis, although usually a symptom of injured lung, may

take place in non-penetrating wounds, and even in injuries of the lung it may be absent; hence the surgeon must be very cautious in relying upon individual symptoms.

Thus, then, there are no absolute signs upon which we can decide; we must await the issue, and maintain a strict watch for any symptom or complication which may set in; our prognosis must be guarded, and must always be considered unfavorable for at least four or five days, before the patient can be pronounced to be out of danger; and in expressing any opinion, it must be recollected that the surgeon is not bound to state whether a wound has penetrated the chest or not.

The primary complications which may ensue in this class of injuries are, emphysema, pneumothorax, hernia of the lung, hæmothorax, and the presence of foreign bodies in the wound or cavity. The secondary, or subsequent, complications are, pleurisy, hydrothorax, empyema, fistulous openings, contraction of the side of the chest, etc. These will be alluded to in their appropriate place.

The treatment will differ but little from that laid down in non-penetrating wounds, viz., the removal of foreign bodies, the arrest of hemorrhage, the immediate closure of the external wound, and strictly enforcing the recumbent position until the period of danger has passed over. The patient must be kept on low diet, and be carefully watched in the interim, and the slightest indication of any untoward symptom is to be treated with energy, according to the instructions given further on.

A curious complication of a penetrating wound without lesion of a viscus is the escape of an uninjured lung through the aperture, constituting a hernia of the lung, or *pneumocele*. There are two varieties, both of which are comparatively rare; the one occurring at the time of the infliction of the wound, and called immediate, the other taking place after cicatrization of the external wound, and called consecutive.

The immediate variety is seldom observed, for in general the escape of the lung is difficult, owing to the tendency of the external air to find its way in through the wound during respiration, and thus prevent any protrusion by pressing the lung away from the wound; the hernia, therefore, must take place before the air has time to enter the chest; and the following explanation of its production has been offered. If there be a large wound, and the chest be at the time suddenly contracted with direct closure of the glottis, the air in the lung, not being able to escape by the trachea, becomes pent up in the air-cells, distending and forcing the organ against the parietes, and causing its escape where the latter are deficient. The most frequent situation in which wounds are liable to be followed by hernia of the lung, appears to be at the anterior part of the chest, on a level with the nipple; and this is said to be due to the greater mobility of the lungs in this region, the rarity of any adhesions, and the nearer approach of the wound to the free edge of the lungs, which would more readily find exit. The size of the hernia varies from that of a small marble to that of a cricket-ball, and it forms a more or less globular mass, consisting of the lung-tissue, covered by its own pleura, and having no investing sac; its base is constricted, and encircled by a kind of neck, formed of the external wounded integument and the tissues in the intercostal space. The protruded lung may be at first simply congested; but this congestion may increase to such an extent that the lung may assume a very deep black color, without, however, any loss of vitality; but when the constriction continues, and the congestion and exudation increase, together with long exposure, gangrene will ensue, and sloughing off of the whole mass take place, constituting a natural cure. The prognosis of these cases is generally favorable. The treatment will depend chiefly on the state of the lung, and the length of time which has elapsed since its prolapse: if the prolapse be recent, and the lung healthy in appearance, it may be reduced by careful and moderate manipulation, care being taken not to injure its delicate structure in so doing; should, however, this be impracticable, owing to the very great constriction of the neck, the latter, provided it be formed entirely of the soft structures, may be cautiously divided, care being taken to avoid wounding the lung or the intercostal vessels. If the lung be in a gangrenous condition, it may be left to nature to throw it off by sloughing; or it may be surrounded by a ligature, and tied; or it may be excised, in order to expedite matters: all these measures have been severally and successfully tried. Thus, Rollande cut the prolapse off, and powdered the surface with astringents, and with success: Tulpius tied the pedicle, and excised the remainder; the patient recovered in fifteen days, having had only a slight cough, and died six years after, when, on examination, the lung was found adhering to the pleura, at the seat of injury, but without notable alteration in its structure: Fabricius relates a case, in which the hernia was cauterized with the hot iron, and a recovery effected, the patient living many years: Ruysch details a case in which a ligature was applied, and the mass allowed to slough off, and with favorable results. These instances are introduced here as showing how a delicate organ, like the lung, may resist

such measures, and not as examples for pursuing the same line of treatment, which is too hazardous, risking the production of pneumonia, and other serious mischief. It is certainly more rational and harmless to leave the hernia alone, under all circumstances, where we are unable to reduce it.

Mr. S. Cooper (First Lines of Surgery, p. 460) mentions a case brought to him at Brussels after the battle of Waterloo. The protruded piece of lung was of a long, narrow, tongue-like form, and severely contused. The wound had been made with a lance. He thought at first of cutting the protrusion off, but the bleeding made the inclusion of it in a ligature necessary. The patient, he believed, did not ultimately recover.

An immediate hernia of the lung may occur without any external wound, as observed in rare cases of extensive comminuted fracture of the ribs; here the lung is generally injured, and the lesion itself is so severe as to be attended with almost immediately fatal results. It has also been described as having taken place during violent straining in the efforts of parturition.

The consecutive variety is when the protrusion takes place after the external wound has closed: thus Velpeau records the case of a man, aged twenty-nine, who received a sword-thrust at the inner side of, and a little below, the left nipple; he lost much blood, but had no hæmoptysis; the wound healed in six weeks, and in three months and a half after the injury he was admitted into the hospital with prolapse of the lung; the latter was found fixed in its present position, and was therefore left alone. In this class of cases the lung is covered by integument; the development and progress of the protrusion is very slow, and it may sometimes attain a considerable size. The signs of this occurrence will be, the appearance of a soft tumor, which is more or less circumscribed, elastic, and indolent; the integuments covering it are perfectly natural, and without any change of color. The swelling moves simultaneously with respiration, expanding in expiration and diminishing in inspiration; it enlarges equally at all points during coughing; and if respiration be suspended for some time, the tumor disappears. On manipulation it crepitates and imparts an impulse on coughing, and the depression in the parietes can be readily felt. On auscultation, it emits numerous vesicular bruits; the respiratory murmur is normal, but is louder and less mellow than in the natural situations.

The treatment will consist in protecting this hernia from external injury, and in preventing the further protrusion of the viscus: this may be done by means of carefully-adjusted pads and bandages: some have recommended the application of a hollow padded truss, to be made on the same principle as that of the umbilical truss.

Congenital and spontaneous hernia of the lung are exceedingly rare; these varieties do not come under our consideration in this work.

A wound of the lung may be superficial or deep; and when arising from external wound, it may be either of the incised, punctured, lacerated, or gunshot variety; but when produced by fractured ribs, it is generally of the lacerated kind. The incised wounds are the most dangerous, as they almost always give rise to immediate hemorrhage and escape of air; these lacerated wounds are next in severity, on account of the retractility of the lung-tissue; punctured wounds, such as are caused by a stab, are the simplest form, and offer a more favorable prognosis;—gunshot wounds will be specially considered in another essay (see Vol. III).

Three conditions generally take place when the lung is wounded,—the escape of blood or hemorrhage, the escape of air from division of the air-vesicles or tubes, and a more or less collapsed state of the organ. The escape of blood may take place into the parenchyma of the lung, causing ecchymosis, or a kind of pulmonary apoplexy, and this is generally met with in superficial wounds, and in the punctured variety; it may escape into the air-tube, and be coughed up with the sputa, constituting hæmoptysis; it may pass through the parietal wound externally; or it may flow freely into the cavity of the pleura, producing hæmothorax. The escape of air may likewise find its way into each of the above situations, viz., into the lung-tissue, causing lobular emphysema, as observed in punctured wounds; into the bronchi, mixing with the blood and sputa, and forming a mixture of a frothy red character; into the pleural cavity, inducing pneumothorax; or it may escape externally through the parietal wound, but more generally it becomes diffused into the subcutaneous cellular tissue, producing more or less extensive emphysema. The collapse of the lung may or may not take place, and this will depend a good deal upon the antecedent circumstances; where a lung has become adherent from old pleuritic adhesions, no collapse will ensue, nor any escape of air or blood into the pleura; hence a favorable issue will be expected.

The repair of a wounded lung may take place in a few days; slight inflammation and exudation of plastic material ensues, causing a partial hepatization, then organization of the thin plastic effusion, when contraction and cicatrization follow; all of which may be completed in from ten to fifteen days. In a few rare instances, im-

mediate union has been proved to have taken place.

The symptoms diagnostic of a wounded lung, excluding the primary and secondary complications (viz. emphysema, pneumothorax, hæmothorax, pleurisy, pneumonia, etc.), are the following: 1. The escape of blood and air through the external wound, of a pale red and frothy character; this symptom will be a strong presumptive evidence, but its absence by no means indicates that the lung is not wounded: there may be an influx and efflux of this frothy blood during inspiration and expiration, should the wound in the lung be opposed to the external one. 2. The issue of blood mixed with air and mucus from the mouth during the efforts of coughing; and this is always to be regarded as a dangerous sign, for bleeding is generally abundant in severe wounds of the lung, and in such wounds, the complete expulsion of the blood being impossible, it accumulates in the tubes, producing a choking sensation, and may suffocate the patient. 3. A deeply fixed pain in the chest, and a considerable degree of irritation and tickling in the larynx, inducing a constant desire to cough. 4. Dyspnœa and difficulty in respiration, owing to partial collapse of the lung, or pressure upon its structure.

The constitutional symptoms are, in the first instance, on receipt of the injury, those of collapse, arising either from shock or great loss of blood: this symptom need not excite alarm, unless it extend over a protracted period. After a short time reaction ensues, and to this condition the surgeon directs his chief attention: inflammation and inflammatory fever, pleurisy and pneumonia, are next to be apprehended, and to be warded off if possible: the symptoms and treatment of these complications do not come within the province of this work.

The prognosis of wounded lung must generally be regarded as unfavorable, even when unattended by any dangerous complication.

The local treatment will consist in arresting any hemorrhage from the superficial vessels, in removing all extraneous bodies, and in closing the external wound as quickly as possible, so as to prevent air being drawn into the chest; and then confining the chest to a state of repose by carefully-applied strips of adhesive plaster, extending from the spine to the sternum. The external application of ice to the chest has been used in severe hæmoptysis, and with the best effects. The constitutional measures will comprise the adoption of such remedies as are appropriate for the particular stage in which the patient is found: thus in the stage of collapse it is not desirable to interfere, for collapse is the means by which hemorrhage is restrained, by allowing coagulation to take place in the divided vessels. The patient should be left in the position in which he is found, or be carefully carried to some more convenient locality; the room or place should be cool, and every measure tending to prevent hemorrhage should be adopted. In the stage of reaction much energy, discretion, and sound judgment must be displayed by the surgeon, and his attention must be mainly directed to the degree of severity of the hæmoptysis, dyspnœa, and thoracic complications: total abstinence from food and exciting drinks must be enjoined for the first few days; the internal exhibition of ice and cold diluents is acceptable; the judicious and prompt use of the lancet will cut short a severe hæmoptysis, and will tend to prevent the subsequent development of inflammation. Venesection should be performed in the semi-erect posture, and the blood taken *pleno rivo:* and we should bear in mind that the object of the venesection is not so much to take away blood as to make a sudden impression on the general system, so as to induce an artificial collapse. Dr. Macleod remarked that the cases of gunshot wounds of the lungs, in the Crimean campaign, which did best, were those in which early, active, and repeated bleedings were had recourse to. The employment of the remedies prescribed in case of hæmoptysis may be used with effect, such as sulphuric acid, in large doses, acetate of lead, etc. In the stage of inflammation, the treatment will comprise the adoption of the measures detailed in works on the practice of medicine, under the headings pleurisy, pneumonia, etc.

The following complications, although generally associated with wounds of the lung, may occur from other causes. We have had occasion to mention these complications incidentally, but shall now describe each separately.

a. Emphysema, or the infiltration of air into the subcutaneous cellular tissue, when occurring in the region of the chest, may be due to one of four conditions: the first, and by far the most frequent form arises from fracture of the ribs, where the broken bone has penetrated the pleura and entered the lung, allowing air to escape: the second, from penetrating wounds of the lungs or bronchi; where on inspiration the air received into the lung escapes from its wounded part into the chest, and on expiration is forced out through the external wound, diffusing itself in the cellular tissue; if the external opening be large and directly corresponding to that in the lung, no emphysema may take place, but in oblique and punctured wounds it is almost always present, and increases during every successive act of respiration: the third,

from penetrating wounds of the pleura without any lesion of the lung, where the air enters from the exterior during each inspiration, and on being forced out again at expiration, cannot entirely escape, but diffuses itself under the integument; the fourth, and rarer form proceeds from rupture of the air-cells without any external wound or fracture; this latter is generally found occurring in idiopathic emphysema, and arising from pathological causes, such as the bursting of a vomica; but it may be observed in traumatic cases, as from violent efforts while holding the breath in parturition, and in the rare instances of rupture of the lung from external violence without fracture or wound: and we may here include those cases in which the air makes its way into the posterior mediastinum, travelling up through the superior opening of the chest into the cellular tissue of the neck, and then diffusing itself through the body.

The symptoms of emphysema consist of a swelling of the integument, commencing at the seat of mischief, and gradually and progressively increasing in all directions, the skin remaining of a perfectly natural color; this swelling has a peculiar and distinctive character, which renders its diagnosis easy, viz., a crepitating and crackling feel under pressure, by some compared to the feeling of a dry bladder half-filled with air—it is elastic, but the air may be made to change its situation by digital pressure; it speedily returns, however, on removal of the finger, and is thus unlike œdema and anasarca, which pit on pressure, and remain so for some time: there is no attending pain. In some cases, where the wound of the lung has been very large, it may extend from head to foot in an incredibly short time; the patient being, as it were, blown out to an enormous size. The constitutional symptoms will depend upon the pressure exerted by this diffused air upon important organs, such as the trachea; its diffusion into the mediastinum and into the pleural cavity; when the patient will complain of tightness of breathing, followed by increased difficulty, which will become almost insupportable, so that he cannot lie down: impeded aeration of the blood and obstruction to the circulation soon show themselves, by the livid red, swollen, and suffused countenance, the weak, contracted, and afterwards irregular pulse, cold extremities, and, if this condition be not relieved, death by suffocation.

The prognosis is in general very favorable, except in cases of extensive wounds.

The local treatment will in some measure depend upon the nature of the cause: thus in emphysema from fractured ribs, a question arises whether or not a bandage or strapping should be applied.

Abernethy[1] speaks in favor of this practice: "Pressure by bandage not only hinders the air from diffusing itself through the cellular substance, but serves to prevent it from escaping out of the wounded lung, and of course facilitates the healing of the wound, which would be prevented by the constant transmission of air. Its early application, therefore, will often prevent a very troublesome symptom, whilst at the same time, by keeping the fractured bones from motion, it greatly lessens the sufferings of the patient." Samuel Cooper,[2] on the other hand, remarks: "When emphysema is complicated with a fractured rib, the latter injury is unquestionably a reason in favor of a bandage. But whether the pressure of the roller will be useful or hurtful with respect to the emphysema itself, or the state of the lungs and respiration, may be questionable. As for its tendency to assist the diffusion of air in the cellular tissue, this circumstance does not appear to me important, because the air thus diffused, much as it disfigures the patient, is nearly harmless, at least so long as the great serous cavities and the interlobular texture of the lungs remain uninflated; a danger, also, which no bandaging has any tendency to prevent. Neither will a bandage have so much effect in hindering the diffusion of air as scarifications, with this important additional consideration, that punctures, or small incisions made over the broken rib, prevent the spreading of the air, by letting it escape, while a bandage can only do so by more or less resisting its escape from the cavity of the pleura, which mode of operation in some cases would dangerously interfere with the continuation of respiration by the lung of the opposite side."

It appears best to be guided in this respect by the patient's sensations. If moderately firm pressure on the injured part of the chest with the hands affords relief to the breathing, it will be right to make trial of the bandage; but if this appears to increase the pain or the dyspnœa, its use must be abandoned. Some surgeons are great advocates for making punctures, or small incisions, in emphysema; but in general they are not requisite, and should form the exception rather than the rule, to be employed when the air has diffused itself over a great extent of surface, and not to be performed over the fractured bone if it can be avoided. Where emphysema is due to the external air being drawn in through a wound during respiration, the treatment will be to force out again as much air as possible, and to close the wound. Where it is due to penetrating wounds of the lung, is the external wound to be closed or left open? Both plans are liable to objection; thus, if the wound be closed, there is no direct vent for the air to escape, and the effusion continues to extend more rapidly; and, on the other hand, if the wound be left open, the external air may be drawn in and increase the mischief. [Both these

[1] Surgical Works, vol. ii., p. 179.
[2] Surgical Dictionary, 7th edit., p. 489.

objections may be met, by the introduction of a large canula through the wound into the pleuritic sac. And in case of hemorrhage from a wound in the lung, the collapse of the lung would secure rest to it, allow the vessels to contract and coagula to form, and thus prove the best means of arresting both the emphysema and the hemorrhage.]

Larrey[1] gives an excellent case in point: "The emphysema arose from a wound of the lung by a lance. The whole body was prodigiously swelled; the integuments so distended that the limbs were inflexible, the eyes buried, and the lips so enlarged that nothing could be introduced into the mouth. The pulse and respiration were scarcely perceptible, and the voice feeble and interrupted. The lance had entered obliquely, under the lower angle of the scapula, and although the external and internal orifices of the wound were not parallel, the surgeon had applied adhesive straps, and closed the external one. Hence the air, as it escaped from the lungs, distended the cellular tissue." Larrey immediately removed the dressings; and with a bistoury made the opening in the pleura and skin parallel. Cupping-glasses were then applied over the wound, and quickly filled with air and blood. The lips of the wound were now brought together, and kept so with a suitable bandage. Cupping-glasses and scarificators were applied to various parts of the body; and in others incisions were made with a scalpel. The patient recovered.

The constitutional measures will be, to relieve any urgent dyspnœa, to diminish the violence of the respiratory efforts, and to lessen the heart's action, taking care not to depress the patient too much. Antimony and ipecacuanha are the most essential remedies, given in full and repeated doses. Venesection must be employed where there is much pulmonary congestion and oppression of the circulation.

b. Pneumothorax is when the air is confined to the cavity of the pleura, and is generally concomitant with emphysema, so that the two might be treated of together; however, to render the subject less complicated, they are described separately. The causes of this accident are the same as those of emphysema, and the same remarks apply to it. When it occurs in a moderate degree and in conjunction with emphysema, it does not attract the surgeon's notice; but his attention is at once arrested when it begins to interfere with the lungs, and compresses them towards the spine and centre of the thorax. Pneumothorax may also arise from disease of the lung, especially in phthisis; hence its study is more appropriately referred to in works on medicine. In this place, reference will be made only to its symptoms and treatment in connection with injuries and wounds of the chest. The symptoms are, urgent and distressing dyspnœa, tympanitic resonance of the chest on percussion, amphoric respiration, and a kind of metallic tinkling or a ringing metallic resonance on auscultation, if the lung is not too much compressed.

The treatment will consist, when the symptoms are urgent and threatening, in allowing the air to escape externally, either by enlarging the wound, or, if there be no wound, by introducing a trocar and canula, as in paracentesis thoracis, described a few pages further on.

c. Hæmothorax is hemorrhage into the cavity of the pleura.

This is so remarkably well described by John Hunter,[1] in his treatise on "Gunshot Wounds," that we cannot refrain from quoting the following remarks. "In the cases of stabs, especially if with a sharp instrument, the vessels will bleed freely, but the external wound will collapse and cut off all external communication. If the lungs are wounded in the same manner, we must expect considerable bleeding from them, and this bleeding will be into the general cavity of the thorax (if the lungs at this part have not previously adhered there), and likewise into the cells of the lungs or bronchiæ, which will be known by producing a cough, and, in consequence of it, a bleeding at the mouth; for the blood that is extravasated into the air-cells of the lungs will be coughed up by the trachea, and by that means will become a certain symptom of the lungs being wounded; but that which gets into the cavity of the thorax cannot escape, and therefore must remain till the absorbents take it up, which they will do, if it is only in small quantity; but if in large quantity, this extravasated blood will produce symptoms of another kind."

The symptoms will depend, in a great measure, on the quantity of blood poured out within a definite period. Where the blood is effused immediately and in large quantities, there will be all the signs of internal hemorrhage, and death speedily ensues, owing to the immense loss of blood, and suffocation from pressure on the lungs. This generally takes place in extensive wounds of the lung, but may also occur from wound of the large vessels in the chest, or even from wound of the intercostal vessels. The signs are, great oppression and uneasiness, restlessness, and sitting up in bed, with the body bent forwards; the countenance and surface become deadly pale and cold, and this is followed soon by syncope and utter prostration, the patient lying almost motionless in bed, with the legs drawn up, and an occasional heaving of the chest; with dilated pupils and glassy eye, clammy perspiration and weak fluttering pulse.

[1] Mém. de Chir. militaire, t. iv.

[1] Hunter's Works, by Palmer, vol. iii., pp. 567 et seq.

Where the effusion of blood takes place slowly, recovery may be anticipated, and the symptoms of such effusion may be well illustrated from Hunter's work. He says: "The symptoms of these accidents are, first, a great lowness, which proceeds from the nature of the parts wounded, and perhaps a fainting from the quantity of blood lost to the circulation; but this will be in proportion to the quantity and quickness with which it was lost. A load in the breast will be felt, but more from a sensation of this kind than from any real weight, and a considerable difficulty in breathing. This difficulty in breathing will arise from the pain the patient will have in expanding the lungs in inspiration, and will also proceed from the muscles of respiration of that side being wounded; and this will continue for some time, from the succeeding inflammation: it will hinder the expansion of the thorax on that side, and of course in some degree of the other side, as we have not the power of raising one side without raising the other; and if wounded by a cutting instrument, the lung of that side, not being able to expand fully, by the cavity of the thorax being in part filled with blood, will also give the symptoms of difficulty of breathing. The patient will not be able to lie down, but must sit upright, that the position may allow of the descent of the diaphragm, to give room in the chest."

The diagnosis will depend on certain rational and physical signs: the rational are, firstly, the symptoms peculiar to all abundant hemorrhages, such as syncope, vertigo, paleness, etc.; and, secondly, the functional disturbance of respiration, such as dyspnœa, short and hurried breathing, continued agitation and change of position. These symptoms are by no means conclusive, as they may be present without any effusion in the chest; and, on the other hand, patients may die of effusion of blood in the chest, without any serious impediment to the respiration. The physical signs are more to be depended upon: they are ascertained; 1st, by mensuration, which enables us to detect the enlargement of the chest on one side, the bulging of the intercostal spaces, and the diminished mobility of the ribs; 2d, by percussion, which will indicate dulness, or even a complete absence of all resonance; 3d, by auscultation, which will detect an absence of respiratory murmur, and by careful watching may even enable one to trace the effusion as it increases upwards; 4th, by succussion, either felt by the patient or produced by the surgeon: where present, it is a good test, but it is often unattainable; 5th, by the appearance of ecchymosis in the lumbar region at the base of the chest, according to Valentin and other surgeons, who describe it as taking place several days after the injury, and as extending from the angle of the false ribs towards the quadratus lumborum muscle, and as being of a deep violet color, in consequence of a transudation of the blood from the chest: however, this sign is not always present, and its absence may deceive the surgeon, as happened to Saucerotte, who declined to perform paracentesis because there was no ecchymosis, and yet, on examination after death, a pint of blood was found in the chest.

The treatment considered to be most judicious, is to close the external wound, and to allow the effused blood to coagulate if possible, and thus form a plug against further hemorrhage; the effusion may prove to be inconsiderable, and provided no air has decomposed the blood, and there be only slight subsequent inflammation, the whole may become absorbed. Should, however, the effusion increase, and cause the above-named symptoms, paracentesis must be performed. Some recommend that the external wound should be kept open, and the patient placed in such a position as to enable the fluid blood to flow out, and to persevere in this measure; Ambrose Paré mentions several such cases as being successful. Others, again, prefer enlarging the external wound, so as to allow a more speedy escape for the effused blood; and this also has been attended with success in several instances. With regard to the attempts at the removal of the blood by means of a tube and pump, this method is attended with too great a risk, as the pleura and lung may be injured; and in respect to the injection of fluids into the chest to soften down and break up the clots, as has been actually proposed, this would be only substituting one effusion for another.

d. Penetrating wounds of the chest, complicated with the presence of foreign bodies, are always to be considered dangerous, inasmuch as they may set up inflammation and its consequences. The foreign body may be lodged in the parietes, or it may enter the pleural cavity and fall upon the diaphragm; or, again, it may pass into the pericardium; generally, however, foreign bodies enter the lungs or heart: in rare instances, especially if the substance be small, such as a bullet, it may become encysted, and remain quiescent for years.

When the foreign body is lodged in the parietes, it must be extracted forthwith; but some difficulty may be experienced, as is recorded by Sabatier,[1] in the case of a man aged twenty-seven, who was struck very violently with a knife on the outer part of the fourth true rib; considerable coughing and spitting of blood ensued, and the symptoms were found to depend on the presence of a piece of the knife, which had pierced the rib, and was projecting some way into the thorax. So little of the foreign body was on the outside of the ib, and it was so fixed in the bone, that it could neither be extracted with any kind of forceps, nor even moved in the least with a leaden

[1] Méd. opératoire, tom. ii.

mallet, etc. M. Gérard conceived that an attempt might be made to extract the foreign body by pushing it from within outwards. For this purpose, having put a steel thimble on his index finger, he introduced it into the cavity of the thorax, and thus succeeded in pushing out the piece of the knife. The patient recovered.[1]

Malle, in 1843, trepanned the fifth rib, in which the blade of a knife was impacted (which could not be seized with forceps). Recovery ensued: but this is a dangerous proceeding, on account of the neighborhood of the pleura.

When the foreign body has entered the pleural cavity, its presence is rendered very obscure in consequence of the speedy inflammation, and the almost necessarily ensuing empyema. Its diagnosis must be based upon: 1st, the penetration of a body, or ball, which has not passed out, and which is followed by thoracic symptoms; 2d, the absence of all signs of wound of the lung; 3d, irritation and inflammation of the diaphragm, from the ball or foreign substance gravitating to the bottom of the chest.

In the case of policeman Thain, who was shot whilst bringing a prisoner from Hamburg, the symptoms were at first so slight that the wounds were regarded as being superficial; but after several days, sudden symptoms of empyema set in, together with great diaphragmatic pains and dyspnœa, and speedy death. On examination, one ball was found lodged in the intercostal space, another in the diaphragm, and a third was rolling about loose in the chest; but the lung was uninjured.

Larrey was more successful, for in one of his cases he made an incision into the chest, and, after evacuating about twelve ounces of pus, he succeeded in removing the ball by means of a polypus forceps, having previously ascertained its presence by the introduction of a sound. The general effects of such injuries are pleurisy, empyema, hectic fever, and death.

When the foreign body has entered the lung, an unfavorable prognosis must be given; but some remarkable instances of recovery are on record.

Mr. South[2] mentions the case of a sailor, aged nineteen, whose chest was transfixed by the bolt of the trysail-mast (five inches and a half long, and two inches and a half wide). It entered between the fourth and fifth left ribs, fracturing the fourth about one inch and a half from the sternum, and made its exit between the eleventh and twelfth ribs, four inches to the left of the spine. There was difficult breathing, hæmoptysis, and threatening suffocation. The wound was closed by lint and strapping; he was freely bled, both locally and generally, and put under the influence of mercury. He recovered and went to sea, was shipwrecked twice, and saved his life by swimming a considerable distance. He was seen ten years afterwards, and was then quite well. Velpeau[1] cites the case mentioned by Guillon, that of a convict who died at Rochefort, and in whose chest was found a part of a fencing foil; this had traversed the chest from one part to the other, and one of the extremities was implanted in the rib, while the other end was fixed in the spine; the middle part was in the centre of the lung, surrounded by calcareous deposit. It was ascertained that the wound took place fifteen years before, and there was no suspicion of the presence of a foreign body. In the Museum of the Royal College of Surgeons of England is recorded the case of T. T., aged thirty-five: the shaft of a chaise was forced between the ribs on the left side, through the cavity of the thorax behind the sternum, and made its exit between the ribs on the right side, without injury to the large vessels, lungs, etc. It was withdrawn, and he walked up two flights of stairs to bed; he had difficulty of breathing, pain and weight in the chest, vomiting and hiccough. He was bled very largely and blistered. He recovered, and lived for five years without inconvenience, when he began to suffer from difficulty of breathing and irregular action of the heart. He died ten years after the accident. The lungs were adherent to the parietes, and the pericardium entirely adherent to the heart, which latter was larger than usual. [Dr. G. W. Brown, of Port Carbon, relates (Trans. of Med. Soc. of State of Pennsylvania, 1877, p. 730), the case of a boy aged fourteen, who while running came in contact with the shaft of a wagon, which passed through his chest, entering about one inch below the left nipple; he was three times raised from his feet by the rearing of the horse, then seized the shaft with both hands, and freed himself; walked home, and under treatment, recovered. He was in robust health at the time of the report.]

The secondary complications or the consecutive effects of penetrating wounds of the chest have already been cursorily alluded to, viz., pleurisy, pneumonia, and empyema. The symptoms, diagnosis, prognosis, and treatment of these diseases hardly come under consideration in this place, and the reader must therefore be referred on these points to the standard works on medicine; but, at the same time, the surgeon must bear in mind that he is bound to possess an accurate knowledge of all these complications, so that he may be enabled to anticipate and detect the coming mischief, and thus check and repel it by suitable treatment.

However, it has been deemed advisable to enter into some further particulars respecting the operation for the relief of empyema and other effusions in the chest. This operation the surgeon is sometimes called upon to perform, and it behooves him

[1] M. Vidal throws some doubt upon the propriety of this proceeding: he says, "It is not easy to introduce the finger armed with a thimble through an intercostal space; and even should it be practicable, great risk is run of the thimble coming off and falling into the chest on withdrawal of the finger."

[2] South's Chelius, vol. i., p. 441.

[1] Presse médicale, tom. i., p. 151.

well to consider the general symptoms necessitating its performance, and the local manifestations which guarantee its probable success.

The operation is termed paracentesis thoracis, or thoracentesis. Before operating, it is essentially requisite to make an accurate examination of the chest by means of auscultation and percussion, so as to determine the existence as well as the locality of the fluid or air in the chest; and then to select a proper situation for its evacuation, making use of appropriate instruments; as well as to guard against all difficulties which may occur during the operation.

There are many objections raised against the operation, but these, when carefully considered, do not in any way militate against its performance; the following are the chief circumstances urged against it: 1st, the necessary introduction of air into the cavity of the chest; 2d, the impossibility of entirely emptying the chest; 3d, the danger of taking away too great a quantity of fluid; 4th, the impossibility of breaking down old adhesions; 5th, the probable rupture of the air-cells and vesicles; 6th, the production of pleurisy and pneumonia; 7th, the more rapid reproduction of the fluid after the operation; 8th, the possibility of the persistence of thoracic fistula.

These objections do not require to be entered into seriatim in the present essay; we shall therefore merely give the result of twenty-five cases, taken indiscriminately, in which it was performed at Guy's Hospital during a given period. Dr. Hughes, in his summary, remarks that "the operation was performed in twenty-five cases, in some once, and in others several times. Of these cases, thirteen may be fairly stated to have recovered, so far as regards the effusion into the pleural cavity: two may be justly mentioned as having at least partially recovered; one of these has, after seven years, a fistulous opening into the pleura, and the other has still some, though comparatively a very small quantity of fluid in the right pleura, but feels so much better as to be actually in search of employment in his profession. Ten have ultimately died of other diseases, generally connected with that for which the operation was performed, but entirely independent of its performance. Of these ten cases ultimately fatal, six have died of phthisis; one of gangrenous pulmonary abscess of the opposite side; one after three months of chronic pneumonia; one rather suddenly, with hydrothorax in the other pleura; and one, a case of pneumothorax with effusion, of pneumonia and pericarditis."[1]

[1] Guy's Hospital Reports, 2d Series, vol. ii., p. 366.

With regard to the situation in which the operation shall be performed, the place of election, as it is called, three indications have to be borne in mind, viz., to procure a sufficiently depending opening, to avoid wounding the diaphragm, and the intercostal vessels.

Mr. Cock, in his remarks appended to Dr. Hughes's paper in the Guy's Hospital Reports, observes, "In the great majority of instances the existence of the fluid would be most clearly indicated at the lateral and posterior part of the chest, in a position somewhat central between the upper and lower boundaries; and in every case which has come under my own hands I have had occasion to tap below the angle of the scapula, between the seventh and eighth ribs, or the eighth and ninth ribs, and at a point distant from one to three inches from the angles of the bones. Our incapability of judging of the exact position of the diaphragm, and the alterations which are liable to occur about the floor of the chest from recent or old adhesions between the muscle and the base of the lungs, would lead me to deprecate the practice of making a low puncture. When we have the choice of two or three intercostal spaces, I would select the upper or, at any rate, the middle one, as the safest, and least obnoxious to those casualties which may induce a failure in our object: any advantage supposed to result from a depending opening can readily be obtained by adapting the position of the patient to our purpose."

M. Malgaigne's[1] instructions are, that, "to avoid the arteries, the middle third of the contour of the chest, midway between two ribs, is to be selected, and, in order to avoid the diaphragm, the third or fourth intercostal space, counting from below upwards, should be preferred; in France it is usual to select the third space on the left side, and the fourth one on the right, in consequence of the liver." He also states, that the required intercostal space can always be found, in thin subjects, by counting upwards from the twelfth rib; but in fat and well-developed persons there is much difficulty in recognizing it; as a proximate guide it will be about six fingers' breadth below the inferior angle of the scapula; the best method is to take as a starting-point the last rib attached to the sternum, which is the seventh, and, on tracing it round the chest, it will give the sixth intercostal space above it, and the seventh below it.

The various modes of opening the chest are, 1st, by cauterization; 2d, by incision; and 3d, by a trocar and canula, which is termed tapping, or paracentesis.

The proceeding by cauterization is obsolete; the pain and great length of time necessary for effecting its purpose have rendered it quite inadmissible.

The operation of making an incision into the chest has been confined to the extraction of foreign bodies; and in this country it is seldom had recourse to for evacuating fluids from the chest, although it is preferred by some of the Continental surgeons.

[1] Méd. opératoire, p. 532, 3me édit.

It, however, sometimes leads to mischievous results, as liable to allow free ingress of air into the cavity.[1]

The operation by means of the trocar and canula is the one usually recommended and adopted. By Mr. Edward Cock's permission we are enabled to make use of the following extracts from his excellent paper in the Guy's Hospital Reports, where the whole subject is fully discussed.

And, firstly, with respect to exploration previous to performing paracentesis. "Notwithstanding the perfection to which auscultatory diagnosis has been brought, and the exactness with which a practised ear is enabled to appreciate the deviations from natural structure and function within the thoracic cavity, the most experienced practitioner will sometimes be mistaken in his opinion, or, at any rate, puzzled by modifications of disease and conflicting evidence, which tend to obscure the clear signs of the presence of fluid. Under such circumstances it is always advisable, previously to tapping the chest, to explore the part in such a manner as shall, at any rate, inflict no injury on the patient, although its result may convince us of the inutility of a further operation. For this purpose, the grooved needle was invented and used; but, although applicable to many other purposes, it is at best a clumsy and inefficient instrument for exploring the chest, and frequently has left us as much in doubt after its withdrawal as previous to its introduction. The groove is so easily obstructed by the tissues through which the instrument passes, or by small particles of lymph, as to render the escape of fluid, which may really exist, a matter of great uncertainty. An instrument admirably adapted for exploration has been contrived by Dr. Babington. It consists of a needle contained in the smallest-sized canula; this is passed between the ribs into the suspected spot; the needle is withdrawn, and the escape of fluid from the tube at once indicates the existence and nature of the abnormal secretion. A further investigation, as to the size and direction of the cavity, may also be obtained by introducing a fine silver probe through the canula."

Secondly, with respect to the operation itself, Mr. Cock observes: "The trocar and canula which I have found best adapted for general use is about one-twelfth of an inch in diameter, and about two inches in length, exclusive of the handle. I prefer a circular to an oval instrument, as the former is more easily introduced, and does less injury to the intercostal muscles, whose fibres are perpendicular to the long diameter of the oval canula. The small canula has many advantages; its introduction is easy, and attended with little friction; it gives but very slight pain, and it is calculated to elude the nerves and vessels; on its withdrawal, the opening which it has made becomes immediately and permanently closed, thus at once restoring the integrity of the cavity which has been entered; it is adapted to all ages, from the infant to the adult, and can hardly fail to find its way between the ribs, however narrow the intercostal space may be; again, it insures a slow and gradual evacuation of the fluid, and enables us to avoid the admission of air; at the same time allowing a better opportunity for the lungs to expand, and enables us more effectually to empty the cavity." Mr. Cock thus concludes: "It now only remains for me to describe the operation itself, which, as regards the pain it inflicts, is so trifling, that by avoiding all unnecessary display and preparation, the patient may be led to consider it as little more than the sequel of the discipline to which he is occasionally subjected when it is considered essential to make a thorough examination of his chest; the same position of the body being alike adapted for the one process as for the other. It will be found most convenient to let the patient sit *across* the bed, so as to admit of his body being readily lowered and supported over its edge. The spot having been determined upon, it is advisable to make a small puncture in the skin, just at the upper edge of the rib, with a narrow-bladed lancet; through which opening the exploring needle and subsequently the trocar may be inserted. This preliminary step is not absolutely necessary; but as the skin is by far the most impenetrable and resisting of the tissues to be traversed, its previous division will render the introduction and withdrawal of the canula more easy, less forcible, and attended with a minor degree of pain and alarm to the patient. The exploring needle having been first introduced and the presence of fluid ascertained, the trocar and canula may then be carried into the chest through the same track, giving the instrument a slight obliquity upwards, which will enable it to clear the edge of the rib. The depth to which the trocar must be passed will of course depend much on the thickness of the parietes, the presence of fat, muscle or œdema, for which due allowance should be made; and, in most instances, the penetration of the pleura will be appreciated by the sensation conveyed to the fingers of the operator, especially if the integument has been previously incised so as to diminish materially the friction.

"The remainder of the operation consists in getting rid of as much fluid as the strength and condition of the patient will bear, and carefully avoiding the admission of air into the cavity. On withdrawing the trocar, the fluid will at first be found to flow in a steady and equable stream, slightly augmented in force at each expiration. After the lapse of a shorter or a longer period, the flow will become checked at each inspiration, and then the body of the patient should be gently lowered into a horizontal posture, and turned slightly on to the affected side, so as to bring the cavity directly over the opening; and in this position he should be duly supported by assistants. The fluid will now recommence flowing in an uninterrupted stream; and when it again begins to flag, a still further quantity may be obtained, if the state of the patient permit it, by directing an assistant to make steady and con-

[1] M. Vidal (Traité de Path. ext., 1871, tom. iv.), proposes a double operation: in the first instance, he makes an incision through the parietes to the pleura, and then allows the wound to be kept open until suppuration sets in, when he inserts a small fragment of caustic potash, so as to cause a slough, and thus evacuate the contents: this secondary operation may be performed by a bistoury or trocar instead of the caustic. He denominates it the operation "*en deux temps.*"

tinuous pressure on the lower part of the chest, by grasping it on either side with the hand. This may be kept up for a period varying from a few seconds to a minute, until a continuous stream can no longer be obtained, when the canula should be immediately withdrawn. The greatest care should be taken to remove the tube, and thus close the opening, while the chest of the patient is yet in the grasp of the assistant; for, if he relax the pressure while the communication with the pleural cavity be still open, air will infallibly rush in.

"During the whole process of evacuation the unremitting attention of the operator should be directed to the stream of fluid, which he should never allow to become completely interrupted during the effort of inspiration. The admission of the slightest quantity of air is immediately indicated by a peculiar sucking noise, which cannot be mistaken, and which should be the signal for the prompt withdrawal of the canula. The wound requires nothing but the application of a small dossil of lint and a strip of plaster; and the patient may then be laid down in bed."

Of late years M. Chassaignac has introduced a plan of treatment for the healing of sinuses, and a cure of deepseated abscesses and extensive collections of matter, by what he terms "drainage-tubes." His plan consists in procuring an india-rubber tube, having a diameter of about one-sixth of an inch, and perforated at frequent intervals by notching it with scissors; and then introducing this into the abscess or sinus, so as to allow the matter continuously and uninterruptedly to exude through the perforatio

This method has more recently been employed in the treatment of empyema; thus, after the ordinary operation of paracentesis, a firm, long iron probe, somewhat bent, and having a strong piece of silk passed through its eye, is introduced into the opening and directed towards the lower and back part of the cavity; the end of the probe is then made to press against the sides of the thoracic walls, so that it may be felt externally between the intercostal spaces, when an incision is to be made upon it, and the probe brought through the opening thus made. Having secured the drainage-tube to one end of the silk, it is to be drawn through and brought out externally, and the two ends of the tube tied together outside.

The plan has been tried in this country on several occasions,[1] but has not found many advocates; the usual method as above given being generally preferred.

[We think aspiration as a means of diagnosis and a first evacuation is the method most frequently practised in the United States. If pus accumulates a second time (as it almost uniformly does), or if the matter evacuated be offensive, a free opening is made into the chest, the cavity is washed out with a weak solution of carbolic acid, the opening kept free, but covered by a Lister dressing. After-washings are determined by the character of the discharge.

Dr. N. P. Dandridge reports (Cincinnati Lancet and Clinic, 1879, vol. ii., pp. 281–5), a case of empyema following gunshot wound of the chest, successfully treated by drainage and exsection of a portion of rib.]

Fistulous openings may become permanently established, and the surgeon's attention is sometimes directed towards effecting a cure.[1]

2. *Wounds of the mediastina, pericardium, and heart.*—Wounds of the mediastina generally compromise the parts contained therein, such as the large vessels, nerves, œsophagus, etc.; they are, therefore, attended with serious results, and take on the characters of the major lesion. But now and then no important structure is implicated, the weapon or instrument merely entering the loose cellular tissue of which the space is composed; a circumstance already alluded to when treating of foreign bodies in the chest, where a case is related of the anterior mediastinum being traversed from side to side behind the sternum, without any important structure being involved. This class of accidents is rare, and when they occur they are liable to be followed by inflammation of a diffused character, which is exceedingly prone to run on to suppuration, or may by contiguity set up pleurisy and pericarditis. In any case, a guarded prognosis must be given. The symptoms are exceedingly obscure, and are of a negative character only, viz., the absence of signs of pleurisy and pericarditis, and yet the presence of inflammatory symptoms. When suppuration takes place, it will often induce pyæmia and death, without giving any external evidence of its existence. Some surgeons have recommended the trephining of the sternum in cases where deepseated suppuration is anticipated; but this measure can seldom be had recourse to, inasmuch as there is so much obscurity that no accurate diagnosis can be made. Where wounds of the mediastina are complicated with fractured sternum, fractured ribs, wounds of the lungs, heart, etc., the conditions are rendered much more serious.

Wounds of the pericardium seldom occur alone, being most frequently associated with other severe lesions. They are generally complicated with wounds of the heart, internal mammary artery, diaphragm, œsophagus, etc., to which individual lesions

[1] See Med.-Chir. Trans., vol. xlii., p. 231.

[1] On the treatment of fistula after empyema, see Archiv. der Heilkunde, p. 84, 1864. Boinet advocates the injection of iodine into an empyemic cavity.

reference must be made. But when the pericardium is alone involved, the wound will give rise to pericarditis; the symptoms, diagnosis, prognosis, and treatment of which must be learned from the standard medical works. Death need not be the immediate result of a wound of the pericardium, as proved by the case quoted by Sir A. Cooper, viz., that of a man who was wounded by a reaping-hook deeply through the cartilages of the ribs. The wound was small; the man had the appearance of one having sustained a dangerous injury, and in two or three days he complained of much pain in the region of the heart, and a quick, small pulse: he shortly began to swell, and could not lie down in bed; he lived for two or three weeks, and after death an effusion of bloody pus was found in the pericardium. Hennen relates a case, where there was a bayonet wound of the pericardium, and where the patient recovered from its immediate effects, but succumbed to pneumonia three months after. The heart, in this case, was found adherent by long fibrinous bands to the pericardium.

For further references to wounds of the pericardium, see the annexed table from Fischer.

[A case of rupture of the pericardium by a fall is recorded by Lewtas, in the Indian Med. Gazette, 1876–7, p. 296.]

Wounds of the heart are for the most part met with in gunshot wounds, but they may be seen in the other forms, namely, in the incised, punctured or lacerated varieties.

Some authors have divided them into penetrating and non-penetrating wounds, according as they involve the cavities or parietes of the heart; this subdivision is of little practical importance, for both are attended with equally fatal results; death taking place either immediately from hemorrhage or consecutively from acute pericarditis.

The following statistical table of 452 cases of wounds of the heart and pericardium are taken from Dr. Fischer's work,[1] which contains a very exhaustive article on the subject, comprising a short abstract and analysis of all the recorded cases.

[1] Dr. G. Fischer, Ueber die Wunden des Herzens und des Herzbeutels. Archiv. f. klin. Clin. von Langenbeck, 1868. Band ix., p. 571.

Situation of Lesion.	Punctured Wounds.				Incised Wounds.				Gunshot Wounds.				Lacerated and Ruptured Wounds.				Time of Death Uncertain.				Total.	
	Death.		Recovery.		Death.		Recovery.		Death.		Recovery.		Death.		Recovery.							
	Immediate.	Not Immediate.	Proved by Inspection.	Conjectured by Symptoms.	Immediate.	Not Immediate.	Proved by Inspection.	Conjectured by Symptoms.	Immediate.	Not Immediate.	Proved by Inspection.	Conjectured by Symptoms.	Immediate.	Not Immediate.	Proved by Inspection.	Conjectured by Symptoms.	Punctured Wound.	Incised Wound.	Gunshot Wound.	Lacerated and Ruptured.		
Right Ventricle,	2	6	2	...	19	54	5	4	4	10	5	...	2	1	...	...	...	3	3	3	123	Right Ventricle.
Left Ventricle,	...	10	4	...	17	36	1	1	3	9	...	...	5	5	...	...	1	3	4	2	101	Left Ventricle.
Both Ventricles,	...	4	...	...	7	5	2	...	1	1	...	...	1	1	...	...	...	2	2	...	26	Both Ventricles.
Right Auricle,	1	1	...	...	...	10	...	...	1	...	...	...	5	3	...	...	1	1	1	4	28	Right Auricle.
Left Auricle,	...	...	...	...	1	4	...	...	1	...	...	...	3	2	...	...	...	...	...	2	13	Left Auricle.
Septum Ventriculorum,	...	...	1	...	...	2	...	...	...	1	...	...	...	2	...	...	...	...	...	1	7	Septum Ventr.
Apex,	...	...	...	...	...	7	3	1	...	2	...	...	...	2	...	...	...	1	...	1	17	Apex.
Base,	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	...	1	...	...	...	2	Base.
Whole Heart,	...	...	...	...	...	2	...	...	2	...	...	...	8	...	...	1	...	...	3	...	16	Whole Heart.
Right Heart,	...	...	...	...	3	...	...	...	...	...	...	1	...	...	...	...	...	...	...	...	4	Right Heart.
Left Heart,	...	...	...	...	...	1	...	...	3	...	...	...	...	...	...	...	...	...	1	...	5	Left Heart.
Coronary Arteries,	...	1	...	...	...	...	1	...	...	...	...	...	...	...	...	...	...	...	...	...	2	Coronary Art.
Uncertain,	1	1	1	2	6	13	6	5	4	2	...	1	3	1	1	1	1	1	...	7	57	Uncertain.
Pericardium,	...	3	...	...	...	15	2	11	...	1	1	4	1	1	...	4	...	4	1	3	51	Pericardium.
104 Immediate Death,	4	...	...	...	53	...	...	...	19	...	...	...	28	...	...	...						
219 Not Immediate Death,	...	26	...	...	...	149	...	...	...	26	...	...	...	18	...	...						
72 Recovery,	...	...	8	2	...	...	21	22	...	...	6	6	...	...	1	6					452	
57 Uncertain,	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	...	4	15	15	23		
452																						
	40 + 4 uncertain.				245 + 15 uncertain.				57 + 15 uncertain.				53 + 23 uncertain.				Total uncertain, 57.					

Foreign Bodies in Heart and Pericardium.

No.	Foreign Body.	External Entrance.	Duration of Life.	Situation in Heart.	Size and Shape of Foreign Body.	Remarks.
1	Needle.	?	18 days.	Entirely in the wall of right ventricle	3 inches long.	Hypertrophied heart—pericarditis.
2	do.	Sternum.	6 years.	ditto.		Covered with lymph.
3	Ball.	Thorax.	20 years.	ditto.		Hypertrophied cicatrix.
4	Needle.	?	1 year.	Entirely in the wall of left ventricle.	2 inches long, broken and oxidized.	Encapsuled.
5	Paper wadding.	Thorax.	7 hours.	ditto.		Filled half the ventricular wall.
6	Ball.	Thorax.	12 days.	Entirely in the wall of septum ventr.	1 inch long.	Encapsuled—pericarditis.
7	Toothpick, ivory.	?	10 to 12 hours.	In the wall and cavity of right ventricle.	1½ inches.	
8	File.	Thorax.	21 days.	In the wall and cavity of left ventricle.	Broken off.	
9	Splinter of wood.		47 days.	ditto.		
10	Needle.	Thorax.	9 months.	In the wall and cavity of both ventricles.		Head in right and point ¼ inch in left ventricle.
11	Iron stilet.	Thorax.	20 days.	ditto.	4 inches long, 2 lines thick.	Firm in heart, point in right ventricle.
12	Needle.	Œsophagus?	Long time.	In the wall and cavity of right appendix.	1 inch long.	Firm in heart—aneurism of descending aorta.
13	Needle.	?	?	In the wall and cavity of left ventricle.	Rather more than 1 in. long.	Surrounded by fibrin.
14	Ball.	Thorax.	Some years.	In the cavity of right ventricle.	Flattened.	Cicatrix in heart.
15	Ball.	Thorax.		ditto.	do.	Fell out of pulm. artery.
16	Ball.	Thorax.	6 years.	ditto.		Encapsuled — cicatrix in heart.
17	Shot.	Thorax.	67 days.	ditto.		Free — hypertrophied cicatrix.
18	Wooden peg.	Thorax.	5 weeks.	ditto.	3 inches long.	Shot through lung, vena cava, etc.
19	Hair wadding.	Thorax.	26 days.	ditto.		
20	Thorn.	Œsophagus.	1½ years.	ditto.	4 lines long.	Free, covered with fibrin, cicatrix in heart.
21	Bone.	Œsophagus?	8 days.	ditto.	1½ inches long.	Heart stuck in several places.
22	Needle.	Œsophagus.		In the cavity of left ventricle.	Long.	Death from gangrene of lung.
23	Needle.	Œsophagus?		ditto.	Long.	No external wound.

FOREIGN BODIES IN HEART AND PERICARDIUM.—*Continued.*

No.	Foreign Body.	External Entrance.	Duration of Life.	Situation in Heart.	Size and Shape of Foreign Body.	Remarks.
24	Ball.	Thorax.	10 weeks.	In the cavity of left ventricle.		Through pulmonary vein.
25	Pieces of a gun.	Thorax.	7 weeks.	ditto.		
26	End of dagger.	Thorax.	22 hours.	In the cavity of right appendix.	5 inches long.	Passed into lung.
27	Razor.	Thorax.	4 days.	Heart quite transfixed.		
28	do.	Thorax.	6 days.	ditto.		
29	Fish bone.	Œsophagus.		Uncertain—in heart.	1¾ inches long.	Wound of stomach, and diaphragm.
30	Needle.	Thorax.	3 weeks.	ditto.		Hypertrophy and adhesion of heart.
31	Needle.	Œsophagus.	Some days.	Pericardial bag.	1½ inches long.	Loose—rent in right ventricle, through the coronary vessels.
32	Ball.	Thorax.	24 hours.	ditto.		Superf. erosion of right vent.
33	Ball.	Thorax.	14 days.	ditto.		Free; injury of right vent.
34	Ball.	Thorax.	44 hours.	ditto.		ditto.
35	Ball.	Thorax.	52 years.	ditto.		Encapsuled—adhesions.
36	Gold tooth-plate.	Œsophagus.	5 days.	ditto.	2 inches long, 1 inch broad.	Teeth in the œsophagus, pericarditis.
37	Ball.	Thorax.	3 hours.	External to the pericardium.	Small.	Pericardium uninjured; lesion of right ventricle.
38	Needle.	Thorax.	6 to 7 weeks.	In the walls of the thorax—in cartilage of rib.		Injury of pericardium and surface of heart.
39	Needle.	Thorax.	Momentary?	In the walls of the thorax—between ribs.	1 inch long.	Injury of pericardium and right ventricle, not penetr.
40	Needle.	Thorax.		ditto.	About an inch long.	Extracted—healed.
41	Needle.	Thorax.	10 to 12 hours.	In the walls of the thorax, between ribs and sternum.	1 inch long.	Lesion of right ventricle—not penetrating.
42	Needle.	Thorax.	1 hour.	ditto.	1⅞ inches long.	Lesion of aorta and pericardium.
43	Iron pin.	Thorax.	12 years.	In the walls of the thorax in sternum.	1 inch long.	Lesion of base of heart.
44	Needle.	Thorax.	9½ months?	In the walls of thorax under the skin.	1½ inches long.	Extracted—healed.
45	Needles.	Thorax.	21 days.	In the lungs.	Two needles.	Pericarditis—carditis.
46	Needle.	?	2 days?	Pericardial bag.		3 wounds in the aorta.
47	Ball.		15 days.	In the wall of left ventricle.		

[The following cases may be added here: "Boston Med. and Surg. Journal," 1870, p. 92; Biffi, needle in left ventricle, found at autopsy. "N. Y. Med. Record," 1870, p. 83; Dr. D. R. Ambrose, pin encysted in wall of heart. "Med. Record" (London), 1870, p. 232; Hamilton, bullet in heart for twenty years. "St. Bartholomew's Hosp. Reports," 1873, appendix, p. 33; foreign body in heart.—P.]

The symptoms are exceedingly uncertain, but the most important one is the presence of a *lesion* in the neighborhood of the heart, with *external bleeding*, followed by all the signs of sudden *internal hemorrhage;* this latter, however, is by no means so frequent or so considerable as is generally imagined, for the blood poured out into the pericardium soon coagulates, and thus prevents further effusion: again, the blood may make its way into the mediastina or pleuræ, and complicate matters. *Dyspnœa* is by no means a constant accompaniment, for it may be absent, or come on gradually, or become immediately intense. Dupuytren[1] observed a peculiar tremor about the heart, with weakening of the arterial pulsation, attended with an undulous crepitation or peculiar bruit. The *pulse* is often unequal, small, and intermitting. The acute *pain* in the sternal region, remarked by some, is neither constant nor certain. The *position* also of the patient is by no means characteristic, for some lie on the left side, others on the back, without inconvenience, whilst some cannot lie down at all. *Auscultation* is of but little assistance.[2]

These wounds are generally considered mortal, death taking place immediately, or in a few days. Immediate death is generally caused by the sudden arrest of the heart's action, induced by one of two causes: either by the accumulation of blood into

[1] Leçons orales de Clin. chir., 2e éd., 1839, tom. iii., pp. 201 et seq.

[2] Fischer gives the following analysis of the situation of the wound:

258 cases in front of the thorax, of which 165 were on the left side, 30 over the sternum and region of the heart, and 25 uncertain. There were also 5 cases on the lateral region of the chest, 26 cases from wounds of the abdomen, and 11 cases from behind.

He observed that syncope or collapse was the first and most important symptom, and might occur even at the moment of receipt of the injury, or not take place until some time after, and hence he classifies the cases into three categories, according to the rapidity of the development of this symptom.

Thus in 87 cases where it was recorded the following results were noticed.

The first set, where the collapse occurred at the time of the accident, comprised 30 cases, of which 20 were punctured and incised, 6 gunshot, and four lacerated and ruptured wounds. The symptoms lasted from 2 minutes to 4 hours; and death generally followed from a few minutes to 2 months, most frequently from the 6th to the 10th day.

The second set, where the collapse was not immediate, but came on some moments after, were 38; of these 33 were punctured and incised, 2 gunshot and 3 ruptured wounds. In one of these, the wounded person could run 450 steps, another ascended several steps, a third walked 1½ mile. [A case is recorded in the Trans. of the Path. Soc. of London, 1879, p. 278, in which a man received an incised wound of the right ventricle, passing through septum into left ventricle, and out near base of heart, by the blade of a carving knife; walked up a flight of 15 steps, and ran 250 yards; fell down, and died in five minutes afterward. Another, by Dr. J. B. Roberts, of Sandersville, Ga. (Richmond and Louisville Journal, 1871, p. 607), in which a man who was shot through both lungs and right auricle of heart ran 60 yards, and lived an hour.]

The third set, where the collapse did not supervene for some time, but came on during the progress of the case, comprised 19 instances, 16 of which were incised and punctured and 3 gunshot wounds.

In them the collapse was due probably to the giving way of the clot or plug in the heart, and secondary hemorrhage. Such hemorrhage may occur all at once, or may be repeated at intervals; it is generally produced by incautious moving. Some cases were going on well for 28 days, when sudden death took place.

Intense *anxiety and fear* seldom comes on at the moment of the accident, but some little time after, and is considered by Fischer to be due to the compression of the heart and lungs from internal bleeding. It may not come on for some time after, as in the case where there was perforation of the aorta, where the patient walked to the hospital and it was difficult to persuade him to stay, when sudden and intense anxiety with fear came on, followed by death. Death-fear, death-pangs, the peculiar aspect of one having mortal wounds, are often present; then the patient on requesting not to be moved may assume a quiet calmness.

The *weakness* may be due not only to loss of blood, but to the nervous and mental depression and shock, which latter appears to be by far the most important point in relation to these wounds.

The *pain* in these cases Fischer refers to the wound of the pericardium; he regards wounds of the heart itself as little or not at all painful; and agrees with Boyer that the absence of pain is of diagnostic value. He adduces Harvey, Ollenroth, and Bamberger as confirming the complete insensibility of the heart; but on the other hand he quotes cases from Lapeyronie and Reiche, which prove the contrary; in their cases, when the cardiac substance was touched, syncope immediately ensued, and in one case the patient was aroused from his state of insensibility and cried out from intense pain.

With regard to *dyspnœa* and the state of the respiration: Fischer finds dyspnœa recorded in only 70 cases; in 7 respiration was normal; but in general the respiratory movements were difficult, and at variable times dyspnœa came on, endangering life. This dyspnœa appeared to be due to the compression of the heart by the effusion of blood into the pericardium and pleura.

Auscultation furnishes the most varied results; the heart-sounds are sometimes normal; often they are masked and distant, and in some cases altogether absent.

Ferrus and Jobert maintain that an undulatory thrill is a constant and pathognomonic sign; the bruit being analogous to that observed in arterio-venous aneurism.

Fischer observes that there does not exist any pathognomonic abnormal bruit in wounds of the heart, and that sometimes no alteration in the sounds has been observed.

the pericardium, pressing upon the heart and causing cessation of its action, or by a suddenly deranged cardiac innervation depriving the heart of its contractile powers, as seen in those cases of sudden death where little or no blood is found in the pericardium. There are, however, some instances of recovery. Dupuytren, indeed, takes a rather favorable view of these cases, regarding them as not being always mortal, and he instances the fact of acupuncture of this organ, adopted for the cure of cholera at Warsaw, being attended with comparative impunity: he also urges the possibility of a cure, as evidenced by animals killed in the chase, in whose hearts balls and cicatrices of former wounds have been found. Considering the ambiguity and uncertainty of the signs of a wound of the heart, recovery from such supposed occurrence can only be confirmed by the subsequent opportunity of post-mortem examination, as in the case cited by Sanson,[1] that of a medical student who recovered completely in twenty-eight days; he was wounded on the left side of the chest immediately below the nipple, and from the attending symptoms it was conjectured that one of the cavities of the heart had been penetrated; at the autopsy, some lengthened period afterwards, a cicatrix in the heart was visible. The case cited by Velpeau[2] is still more explicit; it is that of a coalman, aged fifty, who died in the Hospital of the Faculty; he had, nine years previously, received a wound in the left side of the chest from a table-knife; the pericardium was found largely opened and adherent to the parietal cicatrix; fibrous lines traversed the whole thickness of the right auricle at a point corresponding to the breach of surface in the pericardium.[3] [In the London Lancet, 1873, vol. i., p. 272, a case is recorded of removal of a needle from the heart on the ninth day, the patient recovering. In the N. Y. Med. Record, 1875, p. 173, Dr. C. L. Ford reports a case of wound of the heart by buckshot, successfully treated. In the Brit. and For. Med.-Chir. Review, July, 1876, p. 205, there is reported a case of bullet-wound of the heart with recovery; on the 20th day the external wound was healed, the cicatrix moving synchronously with the systole of the heart.—P.]

The duration of life after such wounds is variable; and this variation is by some considered to be due to the part of the heart which is involved: thus, Ollivier d'Angers[1] gives the following summary of sixty-one collected cases:

In 29 cases the wound was in the right ventricle.
12 " " left "
9 " " both ventricles.
3 " " right auricle.
1 " " left "
7 " the wound involved either the base or apex simply.

Of the twenty-nine cases of wounds of the right ventricle, with the exception of two, all lived not less than two days, viz., 4, 5, 8, 9, 13, 15, 20, 23, and even 24 days, respectively.

M. Jamain (Thèse de Concours, Paris, 1857) has extended this inquiry, and has endeavored to determine the relative frequency of wounds of the different regions of the heart. In a collection of 121 cases there were—of wounds of the

Right ventricle,	43
Left "	28
Apex and base of heart,	7
Both ventricles,	9
Right auricle,	8
Left "	2
Interventricular septa,	2
Both auricles,	1
Left auricle and ventricle,	1
The whole heart,	1
Coronary artery,	2
No precise indication,	17

In the 121 cases, instant or very rapid death was observed in 21 cases, thus distributed:

Right ventricle,	6
Left "	6
The two ventricles,	4
Non-penetrating wound,	1
Left side of heart,	1
Heart crushed,	1
Wound of heart not indicated,	1
Coronary artery,	1

The following are the statistics by Dr. Fischer on the duration of life in 276 cases, where death was not immediate:

[1] See Nélaton, Pathol. Chir., tom. iii., p. 472.

[2] Traité d'Anatomie chir., tom. i., p. 604, 2me édition.

[3] Mr. Gay has deposited in the Museum of the Great Northern Hospital a heart which had received a punctured wound. The patient lived 9 days; there was reason to believe that the wound did not extend quite through the walls of the left ventricle; but that subsequently the force of the blood caused the remaining portion to give way and thus cause sudden death. The opening is about the size of a No. 5 catheter.

[1] Dictionnaire de Méd., art. "Cœur."

DEATHS NOT IMMEDIATE.

Cases. No.	Time.	Punctured wound.	Incised wound.	Gunshot wound.	Ruptured.
37	1 hour	5	26	3	3
46	From 1 to 24 hours	5	25	8	8
74	1 day to 1 week	7	60	6	1
40	2d week	2	31	2	5
8	3d week	4	3	1	...
3	4th week	...	2	1	...
1	5th week	...	...	1	...
2	7th week	1	...	1	...
1	10th week	...	...	1	...
2	2 months	...	1	1	...
1	6 months	...	...	...	1
4	9 months	1	3	...	...
57	Uncertain	4	15	15	23

LONGEST DURATION OF LIFE.

	Punctured wound.	Incised wound.	Gunshot wound.	Rupture.
Right ventricle, . . .	18 days	18 days	2 months 6 days	12 days
Left " . . .	21 days	9 weeks	10 weeks	8 days
Both ventricles, . . .	8½ months	5 days	....	1¼ hours
Right auricle, ...	Long time	15 days	....	14 hours
Left "	2 days	2½ hours	....	2 days
Septum ventriculorum,	10 days	12 days	12 days	4 hours
Apex, ...	1 day	20 days	7 days	9 hours
Base, ...	....	....	7 days	....
Coronary artery, . . .	8 days	....	....	....
Pericardium, ...	2 or 3 weeks	Several days	2 days	8 days

For reference to these cases, see Fischer, op. cit.

The duration of life does not bear any proportion to the extent of the wound; thus, in the well-known case quoted in most French works of the celebrated first grenadier of France, who received a lance-wound between the sixth and seventh ribs, which implicated the anterior parietes of the left ventricle of the heart, it caused immediate death; and on examination half an hour afterwards, the pericardium presented a rent of four to five centimètres, and contained but little blood; the wound in the heart was very small and very superficial. Again, in the year 1728, one of the ladies of the Sardinian court ran a long gold needle into the chest of her husband, whilst asleep, and caused his sudden death; on examination, the right ventricle was found pierced through and through. The thinness of the parietes of the auricles is not the cause of a more rapid death; thus in the case of the Duc de Berri, whose right auricle was traversed by a saddler's awl, he lived eight hours;[1] and in the case quoted by Blagny,[1] where the right auricle was wounded, the patient survived five days.

The direction in which the wound is made will materially affect the duration of life; thus, if made in the course of the muscular fibres, there may be little or no hemorrhage; but if the heart is cut across, the edges will separate to a great extent, and sudden death occur from the immediate gush of blood.

The following recorded cases are instances of long survival after wounds of the heart. Breschet[2] quotes the case of a man who was thrust against a wall by the shaft of a cart, causing fracture of the sternum and of the fourth, fifth, and sixth ribs, and laceration of the pericardium, with superficial lesion of the left ventricle to the depth of one-third of its substance; he lived twelve days: on examination, there was no fluid in the pericardium, but a

[1 A. Corlieu, "L'Assassinat du Duc de Berri; considérations cliniques sur ses blessures; son autopsie;" Paris Médicale, vol. xxvi., 1879, 17, 33.]

[1] Journal de Médecine, an xl.

[2] Breschet, J., Répertoire d'Anatomie et de Physiologie, 1826, tom. ii.

large quantity of blood in the left pleura. Ferrus relates the case of a man living twenty days with a skewer traversing the heart from side to side. David and Steward found a piece of wood, three inches long, in the right ventricle of a boy, who lived five weeks after the accident. Dupuytren, in his Leçons orales, records in full three cases of wound of the heart; one living nine days, the second three weeks, and the third three days; their perusal will well repay the attention of those interested in such matters. There is a remarkable case of survival for twenty-four hours, related by Dr. Babington:[1] a marine fell upon his bayonet, which entered the abdomen, passed through the sigmoid flexure of the colon, through the stomach, the left lobe of the liver, the diaphragm and pericardium, and traversed the heart near the tricuspid valve; then penetrated the lung, and made its exit at the anterior part of the chest between the second and third ribs on the right side.

[To these may be added the following:

St. Thomas's Hosp. Reports, 1870, p. 237. Mr. James F. West, in an article on Wounds of the Heart, gives a summary of 23 cases. In one, both ventricles having been wounded with a knife, the patient lived 19 years and 7 months.

St. Louis Clin. Record, 1876. Dr. P. S. Conner relates a case of gunshot wound involving both ventricles and the right auricle, the patient surviving 3 years, 2 months, and 13 days.

London Med. Record, 1874, p. 212. Steudener, of Halle, is quoted as recording a case of pistol-ball wound, survived 15 weeks. At the autopsy a cicatrix was found at the apex of the left ventricle, corresponding to the wound of the pericardium; grains of powder were imbedded in the muscular substance of the heart.

London Lancet, 1879, vol. i., p. 658. Sir J. Fayrer gives a case of bullet-wound of heart, survived 72 days; ball found in apex of left ventricle.

Med. Record (N. Y.), 1878, p. 476. Dr. F. M. Holly, Greenwich, Conn.; pistol-shot wound through right ventricle, septum, and aorta (*sic*). Patient survived 55 days. Ball found in left ventricle.

Canada Lancet, 1876, p. 242. Tillaux is quoted as having exhibited at the Société de Chirurgie the heart of a woman who had lived 18 days after receiving two gunshot wounds, one ball lodging in the left ventricle.

Boston Med. and Surg. Journal, vol. vi., p. 243. Broca. Patient lived 15 days after stabbing himself twice. One wound near apex of left ventricle, the other in the pericardium only; both cicatrized.

Am. Jour. of Med. Sc., Oct., 1879. Dr. H. W. Boone, of San Francisco, Cal., relates a case of gunshot wound of the heart surviving 13 days.

St. Thomas's Hospital Reports, 1874, p. 420. Stab of right ventricle; survived for 5 days.

Med. Record (N. Y.), 1871–2, p. 156. G. F. Dudley, St. Louis, Mo. Pistol-ball in the heart 4 days.

The following references to cases of *rupture* of the heart, recorded within the past ten years, may be added here:

N. Y. Med Record, 1871–2, p. 344; Brit. Med. Journal, 1873, vol. ii., p. 462; Indian Med. Gazette, 1874–5, p. 63; Trans. Path. Society of Philadelphia, 1874–5, p. 94; Ibid., 1875, p. 59; N. Y. Med. Record, 1876, p. 210; Med. Times and Gazette (London), 1878, vol. ii., p. 643; Am. Jour. of Med. Sciences, Oct., 1879, p. 566; Brit. Med. Journal, 1879, vol. ii., 991; Progrès Médicale (Paris), 1880, vol. viii., p. 171; Lancet (London), 1880, vol. i., p. 115; N. Y. Med. Record, 1880, p. 518.—P.]

[1] Medical Records and Researches, p. 59.

Much further detail and many curious cases may be found in works on Military Surgery. The popular notion of persons springing up in the air, when shot through the heart, is not verified by facts.

Recovery.—The general idea is, that wounds of the heart are mortal, and even now recovery is considered doubtful by many. But of 452 cases, there were 72 recoveries. In 36 cases, this was proved afterwards by inspection; but in the other 36, the wound was only conjectured from the symptoms present.

Punctured wounds, 10 cases, 8 proved by inspection, 2 from symptoms. Incised wounds, 43 cases, 21 proved by inspection, 22 from symptoms. Gunshot wounds, 12 cases, 6 proved by inspection, 6 from symptoms. Lacerated wounds, 7 cases, 1 proved by inspection, 6 from symptoms. Total number of cases, 72; of which 36 were proved by inspection, and 36 from symptoms. Of these 50 were of the heart and 22 of the pericardium.

I. *Of the Heart.*

Punctured wounds,	10	Needles,	8 cases.
		Stilet	1 "
		Thorn	1 "
Incised wounds,	30	Knife,	10 "
		Dagger,	7 "
		Poniard,	2 "
		Bayonet,	1 "
		Uncertain	10 "
Gunshot wounds,	7;	in 4, balls left in.	
Lacerated and ruptured,	3		
	50		

II. *Of the Pericardium.*

Incised wounds,	13	Knife,	5 cases.
		Dagger,	4 "
		Poniard,	1 "
		Bayonet,	1 "
		Uncertain,	2 "
Gunshot wounds,	5;	in 1, ball left in.	
Lacerated and ruptured,	4		
	22		

The treatment will be mainly directed to prevent and arrest internal hemorrhage, by absolute repose, local and general employment of cold, and early venesection to relieve the heart; and to allay the excited action of the heart by the administration of belladonna and digitalis internally. Where blood has become effused into the pericardium, it has been suggested to lay open the pericardium, and evacuate the blood and coagulated mass, and thus re-

lieve the oppression of the heart; but although this has been recommended, it has not yet been put in practice, probably owing to the difficulty of distinguishing internal hemorrhage into the pericardium from hemorrhage into other important cavities.

Paracentesis of the pericardium is seldom called for; it has been performed between the fifth and sixth intercostal spaces, between the ensiform cartilage and the seventh rib, and by means of trephining the sternum. The operation is best performed in the fourth or fifth intercostal space, either by direct puncture or by incision and subsequent puncture, as in paracentesis thoracis: the precautions and mode of performance are the same.[1]

3. *Wounds of the vessels of the thorax.*—Wounds of the intercostal artery are occasionally met with; thus the vessel has been injured in the unskilful performance of paracentesis, and in the making of incisions into the chest without due anatomical knowledge; an intercostal artery has likewise been wounded in cases of fractured ribs, and in penetrating wounds of the chest. The effects will be either external or internal hemorrhage. The symptoms of internal hemorrhage have been already detailed at p. 590, to which reference must be made. This occurs generally in cases of punctured wounds or stabs, where the blood, not being able to escape externally, passes into the pleural cavity. Where the hemorrhage takes place externally, in consequence of a large and direct wound, a pulsating jet of arterial blood may be observed, which will immediately apprise the surgeon of the nature of the injury; but, generally speaking, the wound is small, and the blood escapes continuously, and not *per saltum*, so that much is lost before the means of checking it can be had recourse to. Sometimes the blood, instead of escaping externally, passes into the tissues external to the chest, as in a case related by Mr. S. Cooper.[2] A young gentleman had been wounded by a penknife, severing an intercostal artery about two inches from the vertebral column; about eight ounces of blood immediately flowed from the external wound, followed by an enormous extravasation of blood under the muscles of the back, intense pain, and high symptomatic fever. In a few days, in consequence of suppuration having taken place, an opening was made, and about a gallon of fluid was discharged, composed partly of pus, but chiefly of putrid blood. The case proved tedious in consequence of the formation of deep sinuses, and life was frequently in great danger; but in the end the patient recovered. It has been suggested, in order to facilitate the diagnosis, to introduce into the wound a piece of card, which will allow the blood to flow out externally along its surface, if the artery be wounded, and internal hemorrhage be suspected.

The treatment of wounds of the intercostal artery will be the enlarging of the external wound, and securing the divided ends of the artery by ligature; but this is by no means easy.

Mr. Harrison, in his well-known work On the Arteries, thus alludes to this point: "In cases of wounds of the thorax, in which an intercostal artery has been opened, the patient may lose a considerable quantity of blood before the surgeon can stop the hemorrhage; the artery lies so deep, and the intercostal space is so confined, that it is almost impossible to hold the artery with the tenaculum or forceps, for the purpose of applying a ligature upon it. The student may form some conception of the difficulty of this operation if he expose an intercostal artery in the dead subject, by dissecting from the surface. This may also lead him to reflect upon the plans which have been proposed for securing this vessel where a ligature cannot be directly applied; he may endeavor to pass a small curved needle round the artery, directing it from within outwards; and should this measure be attended with much difficulty, from the smallness of the incision, he may observe how much it will be facilitated by enlarging the opening. Suppose it were impracticable to pass a ligature round the artery in the living subject, he may learn from his dissection the possibility of compressing it by other means; thus, by placing a ligature on a piece of sponge, and introducing the latter through the wound into the chest, then withdrawing the ligature so as to cause the distended sponge to make pressure of the vessel against the rib, and securing the thread externally over a compress placed over the wound, he may by these means restrain the bleeding."

A variety of methods have been suggested, such as the passing of a ligature of wire around the rib, so as to include, not only the artery, but also the bone and soft parts; the introduction of metal or ivory plates into the chest, drawn from within outwards by means of ribbon or silk thread, so as to compress the artery against the rib. All these methods are unjustifiable, as they are liable to excite severe inflammation of the pleura and lung. Assalini[1] prefers simply cutting the artery across, so as to allow it to retract; and if this plan fail, he recommends the wound to be closed. [An admirable method of checking hemorrhage from an intercostal artery, or the in-

[1] See Clinical Lecture, by Trousseau, in the Clinique de l'Hôtel-Dieu, vol. i.; also Mr. Wheelhouse's successful case, in the Medical Times, Nov. 3, 1855, and Dr. Allbutt's "Clinical Lecture," Lancet, June 12, 1869.

[2] Surgical Dictionary, p. 1491, 7th edition.

[1] Manuale di Chirurgia, pp. 58, 59.

ternal mammary, is to pass the closed end of a "condom" within the cavity and pack the end that is within with a narrow strip of muslin until it is larger than the wound in the chest-wall. Then by making traction on the end of the condom outside, the inner end may be drawn tightly against the cavity end of the wound; and while the condom is thus kept tense, pack the portion left on the outside of the chest with a remaining portion of the strip of muslin and tie a cord on the outside of the mass. In this way the packing is brought against the vessel with sufficient force to prevent bleeding. In a few hours this may be removed by untying the outer end and drawing out the strip of muslin and then removing the condom.] Should the blood find its way into the chest, it is true the consequences will be serious, but not fatal; and if the symptoms require it, the operation for empyema may afterwards be performed. A small quantity of effused blood, however, may be absorbed, and no such proceeding be requisite.

Dr. Hennen[1] says: "Unfortunately, we but too often are disappointed in finding the source of the hemorrhage, and here judicious pressure is our only resource. In some very slight cases I have used the graduated compress with success; but if the sloughing is extensive nothing but the finger of an assistant, relieved as occasion may require, and pressure directed upon a compress placed along the course of the vessel, or so disposed as to operate upon its bleeding orifice, will be of any avail."

Wounds of the internal mammary artery.—The protected situation of this vessel renders its injury exceedingly rare; still there are several cases on record. M. Tourdes has written a special monograph on this accident in its medico-legal aspect: the result he arrives at is, that the lesion occurs on the right and left sides in equal proportion; that in more than half the cases it is accompanied with section of the cartilages, and that this section always exists when the vessel is wounded below the fourth rib: he also remarks that wounds situated at the sides of the sternum from the first to the seventh ribs, and of sufficient depth, should always engage our attention, and be regarded as suspicious.

The results may be: 1, external hemorrhage; 2, hemorrhage into the anterior mediastinum; 3, hemorrhage into the cavity of the pleura; 4, hemorrhage into the cavity of the pericardium; besides, the injury is not unfrequently complicated with wound of the lung, heart, or diaphragm.

The symptoms will be those of hemorrhage, in addition to those of any complication which may exist.

The prognosis is always unfavorable; much internal effusion of blood takes place, and death generally ensues from the hemorrhage.

The treatment consists in compression of the vessel in the same way as above prescribed in wounds of the intercostal artery, and in the application of a ligature on the vessel; although this latter proceeding is exceedingly difficult. In the first three intercostal spaces the artery may be secured with ease; in the fourth space it becomes difficult to reach; the operation is very difficult in the fifth, and almost impracticable in the sixth space. It is performed by making an incision for two inches along the side of the sternum, and in an oblique direction from above downwards, and from without inwards, forming with the axis of the body an angle of forty-five degrees; the centre of the incision to be three or four lines from the border of the sternum. Having divided the skin, cellular tissue, and origins of the pectoralis major muscle, the intercostal space is brought into view; the intercostal muscle is now to be carefully divided upon a director, and the edges drawn apart by retractors, when the artery becomes exposed.

Baron Larrey[1] says that he has seen several cases of wounds of this vessel, and he proposes simply to close the external wound so as to allow of coagulation, and by this means to compress the vessel. He relates three cases of this injury. The first case was a sabre-thrust, which entered the chest for an inch and a half, dividing the cartilage of the seventh rib close to the sternum; there was great effusion of blood, and very severe symptoms, so that it was thought necessary to lay open the wound and evacuate the blood; the man made a good recovery. In the second case, a knife entered above the cartilage of the fifth rib on the left side; the wound was closed, much effusion of blood followed, and severe symptoms set in, so much so, that a puncture was obliged to be made, whereby a pound of blood and clot was evacuated; but the patient lived only twenty-one days. In the third case a knife entirely divided the cartilage of the fourth rib; this was followed by much hemorrhage, which ceased, and the wound was closed; in a few days signs of internal hemorrhage ensued, paracentesis was performed, two and a half pounds of blood evacuated, and a recovery resulted.

Some years ago, a man was admitted into the Meath Hospital, having received a stab of a sharp-pointed shoemaker's knife, about one inch below the right sterno-clavicular articulation, by which the internal mammary artery and vein were wounded. These vessels poured out their blood continually, and in such abundance, into the cavity of the pleura, that the lung became dreadfully oppressed, and it was deemed advisable to perform the operation of paracentesis on the fourth or fifth day after the injury. A large wound was made in the

[1] Military Surgery, p. 337, 2d edition.

[1] Clinique chir., t. iv., p. 101.

operation, in the expectation that it might facilitate the escape of any coagulum, but the precaution was found to be unnecessary, as the blood had remained in a perfectly fluid state, and flowed away with great facility. The quantity of blood thus lost was enormous—it must have amounted to some quarts; and as the wounded vessels still continued to bleed, it is scarcely necessary to add that the patient soon died.[1]

Wounds of the larger vessels of the chest are for the most part fatal, and are attended with all the symptoms of rapid internal hemorrhage, death almost invariably resulting immediately, or in a few hours afterwards. Some rare cases of survival after such wounds are, however, on record; thus Dr. Heil[2] details a case in which a patient recovered and lived twelve months after receiving a stab which penetrated the ascending aorta.

Pelletan[3] writes: "In May, 1802, a young man was brought to the Hôtel Dieu, who, in a duel, had been run through with a foil, which entered above the right nipple and came out at the left loin; the most alarming symptoms were apprehended, but several days elapsed without any serious complaints taking place. The patient was bled twice, and kept on very low regimen. Everything went on quietly for a fortnight, when he began to complain of severe pain in the loins, which was relieved by the warm bath. He seemed to be recovering; he got up, and went to walk in the garden allotted to the sick, but the pain in the loins quickly returned, attended with difficulty of breathing, with constipation, and wakefulness. He became now very impatient and out of temper at not being relieved. On July 15, two months after the accident, there was remarked a deformity of the spine, about the eighth dorsal vertebra. The patient grew rapidly worse, and died in the utmost agony, saying that he felt suffocated; and tore off his shirt, so that his chest might be free from pressure of all kind. On the body being opened, the right side of the chest was found full of blood, coagulated in various degrees; and an opening, the diameter of which was equal to that of a quill-pen, was detected in the aorta, above the crura of the diaphragm. All the adjacent cellular tissue was injected with blood, and three of the dorsal vertebræ were found carious. There was no mark of injury perceptible in any of the thoracic or abdominal viscera."

Breschet[4] relates the case of a wound of the vena azygos, a little below its entrance into the superior cava, which was followed by considerable effusion of blood, and death resulted on the third day from compression of the lung by the effused blood.

4. *Wounds of the œsophagus.*—These are, for the most part, complicated with other injuries, and are more appropriately treated of with wounds of the neck. However, it has been considered advisable to draw attention in this place to wounds of the thoracic portion of the œsophagus, by referring to the following case[1].

A man, aged twenty-four, was stabbed by a bayonet in the anterior and superior part of the chest; it entered between the third and fourth right ribs, one inch from the sternum. He fled from his assassin for half a mile, without feeling any pain; on reaching home he had coughing and spitting of blood, and in an hour after the accident experienced inexpressible anguish; he was lying on his right side, suffering from the least movement, and complaining of intense pain all along the right side of the chest, as far as the haunch. At each inspiration and cough, air escaped through the wound, sufficient to blow out a candle seven or eight inches distant. On the second day, respiration was much embarrassed, but the spitting of blood was arrested after a third venesection. On the third day, on removing the dressings there escaped a large quantity of red fluid, of less consistence than blood; the respiration was more free. Much fluid ran out during the day, and at each time of dressing, and it was suspected to be the fluids swallowed. Oily and colored drinks were given, which in due time stained the dressings. The patient was now prevented taking anything by the mouth, and was fed by nutritious enemata. For four days nothing escaped through the wound, and he made a gradual recovery. Subsequently he had signs of a large effusion in the chest, when on the thirtieth day he vomited and rejected a large quantity of pus; this flow of pus lasted for another fifteen days. He ultimately recovered.

Foreign bodies have passed down the œsophagus and escaped through its parietes into the chest; several cases of the kind are recorded by Fischer, and are referred to in the table on p. 602.

Contusions of the chest, followed by lesion of the contents without any external wound, may be associated with the following effects: firstly, pleurisy, and in rarer instances pneumonia, which come under the more immediate cognizance of the physician: secondly, inflammation of the cellular tissue of the mediastina, running on to suppuration, and producing dyspnœa from pressure on the lung, or causing disease of the sternum, in rare instances assuming the form of a pulsating tumor, owing to the contiguity of the heart, and simulating aneurism.[2]

Thirdly, such contusions may be attended with rupture of the lung; this last accident is rare, but several well-authenticated instances are on record. The symptoms, diagnosis, prognosis, and treatment will be the same as detailed in wounds of the lung,

[1] Porter, On Aneurism, p. 170.
[2] Henke's Zeitschrift, 1837, t. ii., p. 459.
[3] Clin. chirurgicale, t. i., p. 92.
[4] Op. cit.

[1] Boyer, Traité des Maladies chir., tom. vii., p. 220.
[2] Sir A. Cooper mentions the case of a medical student who was supposed to have aneurism, but matter made its way through the sternum, and a thorough recovery was effected.

but in these cases there will be an additional obscurity, viz., the absence of any external lesion, or fracture of the ribs.

Watson, in his work On Homicide, relates the case of a carter, who, being somewhat intoxicated, was thrown off his cart and the wheel passed obliquely over his chest; he expired shortly after. There was no external wound, and no fracture of the ribs; but a laceration of the right lung near to the origin of its vessels, and there were three pounds of blood in the right cavity of the chest; the liver was also lacerated, and blood effused in the abdomen.

M. Gosselin in Mém. de la Soc. de Chir. de Paris, vol. i., has fully entered into this subject, and adduces two cases of ruptured lung from violence, without any external wound or fracture of the ribs, both of which recovered: he remarks that when a rupture takes place there may be a solution of continuity of the pulmonary vesicles without wound of the pleura; or there may be a tearing of the lung-tissue, as well as of the pleural envelope; in the latter instance, air and blood will escape, and the symptoms will be those of hydro-thorax; there will be dulness at the lower part of the chest and sonority at the upper part, a mucous râle or gurgling opposite the site of the rent, metallic tinkling, dyspnœa, frequent respiration, spitting of blood, and sometimes cutaneous emphysema.

In the British Medical Journal for March 5, 1859, there is related the case of a boy, aged seven, who was struck down by a cab, the wheel passing over his chest. He complained of great pain in the belly and on the left side of the chest, which was dull and gave no evidence of respiratory murmur. About four hours after, there was considerable distension of the intercostal spaces, and great dyspnœa; he died on the following day. The ribs were found uninjured, but the lung was extensively lacerated, and the pleural cavity full of blood.

A similar case occurred at Guy's Hospital, but death ensued in two hours, in consequence of the complication of ruptured liver; the lung was ruptured at the lower edge of the middle lobe of the right side, to the extent of three inches; the pleural cavity was filled with air and some ounces of blood, and the lung partially collapsed.

A third case is recorded by Dr. R. B. Donnell, in the Dublin Quarterly Journal, vol. xxxviii., p. 205. It was that of a young man, aged twenty-four, who lived ten days.

[A fourth, by Dr. John Ashhurst, Jr., in the Trans. of the Pathol. Society of Philadelphia, vol. iv., 1871, p. 129; with a table of 19 other cases (this includes the three above given). Other instances are recorded in the St. Thomas' Hosp. Rep., 1871, p. 330; Lancet, 1873, vol. i., p. 767; St. Bartholomew's Hosp. Rep., 1875, Surgical tables, p. 34; St. George's Hosp. Rep., 1877–8, p. 246. In the Med. Times and Gaz., 1871, vol. i., p. 247, a case is given in which the *costal* pleura was uninjured, though the bronchus was torn completely through, and the lung ruptured; the sixth and seventh ribs were fractured; the patient, a boy, had the chest injured by the passage over it of a cartwheel, from above downwards, and lived 19 days.]

Pneumonia or pleurisy may supervene. The prognosis is unfavorable, as the laceration is generally extensive; still, death is not always the result, as seen by the recovery of the cases brought forward by M. Gosselin.

The rupture may be direct, viz., at the seat of injury, or indirect, at some distance off; and M. Gosselin asks, how are we to explain the rupture of the lung without any fracture of the ribs? Is it from shock, as is observed in injuries of the brain? He thinks not: the elasticity and mobility of the ribs are too great, and they resist such shock, without implicating the lung-tissue. Again, is it from extensive and long-continued pressure of the ribs forcing the lungs against the spinal column? The lung is spongy, soft, and composed of cells freely communicating with the bronchi and trachea, and, when compressed at one part, the air escapes into another; and thus the lung accommodates itself and does not tear: on the other hand, in order to press the lungs against the spine, there must be enormous force and pressure; and even then it is impossible without fracture of the ribs.

M. Gosselin offers the following explanation as to the probable cause: that at the time of the injury, when the chest receives the violence, the lungs are suddenly filled and distended with air by a full inspiration, and the air, prevented from escaping by occlusion of the larynx, thus becomes pent up in the lung-tissue, and the lung not being able to recede from the superincumbent pressure, its tissue necessarily gives way.

Fourthly, severe contusions of the chest may be followed by cerebral congestion, owing to derangement of the circulatory and respiratory functions; thus, heavy weights falling upon the chest, or undue and prolonged pressure on the ribs, preventing their free action, as in the fall of earth whilst excavating, may arrest the respiratory functions and induce venous congestion and asphyxia. There may be in consequence epistaxis, ecchymosis of the eyes, congestion of the brain, etc.

Fifthly, contusions may give rise to pericarditis, as evidenced in the following instances:

A child received a blow on the chest, causing great pain and very violent palpitation; he had repeated attacks of hæmoptysis, and died at the end of six months. There was pericarditis and carditis, and a livid sphacelated spot on the heart, which extended into the cavity of the ventricle.

Blancard[1] relates the case of a peasant who was thrown under a cart; he had immediate

[1] Lexicon Med. Renov., 1735.

pain in the chest, and dyspnœa, with a feeling of compression of the heart; after four days he went to work, but soon after had violent fever, oppression, and delirium, with insomnia, extreme thirst, and frequent syncope. He died on the eleventh day. The pericardium was full of sanious pus, and the parietes of the auricles, here and there, ulcerated and softened.

Sixthly, contusion of the chest may be complicated with injury to the heart, causing a rupture of its fibres or its valves. The symptoms and prognosis will be the same as those detailed in WOUNDS OF THE HEART. Death, however, in these cases, is almost always instantaneous, although some have lived for several hours. There is a preparation of a lacerated heart of a child in the Museum of the Royal College of Surgeons, Edinburgh;[1] in the description of which it is stated that a cartwheel had passed over the chest and occasioned instant death, but there was no external wound or fracture of the ribs. Dr. Christison[1] mentions two cases from violence, the one caused by a fall, the other owing to a blow. Mr. Gamgee[2] has collected 27 published cases of the kind; 12 occurred on the right side, of which 8 had rupture of the ventricle, and 4 of the auricle; 10 occurred on the left side, of which 3 were of the ventricle, and 7 of the auricle. In half of the cases the pericardium was intact.

[In 1875, I reported to the Pathol. Society of Philadelphia a case of triple rupture of the heart, in a man struck by the locomotive of an express train. He was carried along in front of it for some forty feet, and then fell over on the other track, sustaining various injuries; was dead when picked up. One rupture was in the posterior wall of each auricle, the third in the inter-auricular septum. Trans., vol. vi., p. 59.—P.]

For further information see Fischer's work on the subject.

[1] See Trans. Edin. Med.-Chir. Soc., vol. i.

[1] Watson On Homicide, p. 96.

[2] Researches in Pathological Anatomy and Clinical Surgery, 1856.

INJURIES OF THE BACK.

By Alexander Shaw, Esq.

Revised by Chas. T. Hunter, A.M., M.D.

Provisions in the Structure of Spine against Common Injuries.

Accidents to the vertebral column derive their chief importance from endangering the spinal cord. It may assist in enabling us to estimate the comparative liability of different parts of the spine to be injured, and the relative severity of the effects in the various kinds of violence to which it is exposed, if we take a general survey of its structure and uses, before entering on the proper subject of this essay.

The spine serves several distinct offices in the skeleton; some of which appear, at first, incompatible with others. It is a pillar for sustaining weight, a girder for connecting distant members, an elastic-jointed mechanism for motion, a supporter of the ribs for breathing, and a tube for containing the most vitally important organ next to the brain, the medulla spinalis. The safety of the spinal cord is secured in various ways. Being lodged in the centre of the column, it occupies neutral ground in respect to forces which might cause fracture. For it is a law of mechanics that when a beam, as of timber, is exposed to breakage, and the force does not exceed the limits of the strength of the material, one division resists compression, another laceration of its particles, while the third, between the two, is in a negative condition. Applying this principle to the vertebral column, it will presently be seen that the

violence which leads to fracture is in the majority of cases directed so as to bend it forward. Consequently, the anterior segment will be subject to compression, the posterior to laceration, and the intermediate will be in a neutral state. Now, the fore part of the spine, by the peculiar structure of the bodies and intervertebral cartilages, is admirably calculated to resist the effects of undue pressure; the back part, by the arrangement of its numerous fibrous and elastic ligaments, is equally adapted to resist the effects of a rending force; and the spinal cord, situated between the two, occupies the place of least danger. Again, the cord is specially guarded by the elasticity and nicely-graduated flexibility of the column. As each vertebra meets the next below at three distinct surfaces of contact—the body, and two articular processes—it follows that, when the superincumbent weight falls upon it, the pressure is distributed through these different lines of support. In the bodies, the force will be broken by the intervertebral cartilages acting as buffers; in the articular processes, which are wedge-shaped, and articulated with the thin edge of one pointing to the base of the other, it will be gradually lessened by the broader portions of both, approximating in proportion to the compression. The mutual interlocking of the adjoining vertebræ, caused chiefly by the ascending articular processes being overlapped from behind, and the descending from the front, has the effect of limiting the motion of any two or three vertebræ within a small sphere, but does not prevent a considerable range in several. There being various grades of flexibility in the different regions of the spine, certain curves are introduced near the respective junctions, to equalize the movements; for, as the force directed on any part must impinge on a series of oblique surfaces, when travelling along these curves, it will be transmitted from one vertebra to another, with gradually diminishing impulse, till exhausted. Another provision for the safety of the spinal cord is seen in the way in which it is attached with its membranes to the interior of the vertebral canal. The cord is small compared to the area of the canal; hence, instead of the theca being in close contact with the osseous surface, as the dura mater is with the cranium, it is separate, except at the foramen magnum. The whole way down the canal, the theca is tacked at intervals to the sides, by those processes which it sends off to inclose the spinal nerves, as they emerge at the intervertebral foramina. Within, the visceral arachnoid membrane is so far apart from the pia mater, which invests the cord closely, that a layer of subarachnoid fluid of considerable thickness intervenes, and surrounds the cord. Thus the medulla floats, as it were, on a water-bed; that bed being hung within the canal by cords, much in the same manner as a sailor slings his hammock in his cabin. The last example that may be adduced of a special arrangement in the structure for averting danger from the cord is suggested by observing the mode of its termination within the vertebral canal. In quadrupeds, and even in man during fetal life, the cord is continued along the whole course of the canal to the sacrum. But in adult man the cord begins to diminish in size at the last dorsal vertebra; it then tapers to a point, and ends opposite the second lumbar vertebra. For the last three inches, it is covered so thickly by the roots of the lumbar and sacral nerves as to be concealed from view. Below the part where the cord terminates, the canal is occupied only by the cauda equina, composed of a leash of long, firm, flexible roots of nerves, together with the theca and other investing membranes. It appears that that curtailing of the cord has relation to the more violent, and as they may be regarded in reference to it, unsafe movements performed at the lumbar region in man compared to quadrupeds. The sudden bendings, twistings, and joltings incident to the base of a flexible column, which rests on a comparatively solid foundation, the pelvis, and which from being upright has the whole superincumbent weight concentrated upon it, are somewhat moderated by the elasticity of the region, as well as by the large sweeping arch formed by the vertebræ there—a curve that may be likened not inaptly to the C-spring of a carriage; yet it may be admitted that shocks which would be harmless to a bundle of roots of nerves like those forming the cauda equina, might be destructive of the functions of an organ of such soft consistence as the spinal cord, had it been prolonged the whole way to the sacrum.

[The arrangement of the dense masses of muscles in the vertebral gutters, supporting the spinous processes on either side and covering the laminæ and the intervening spaces, afford great protection to the spinal column and its highly important contents. These muscular masses, in consequence of the large proportion of fibrous tissue entering into their constitution, serve not only to break the force of direct injuries, as blows, falls, etc., but also to arrest the progress of balls and other foreign bodies in their course towards the spinal column.]

Weakest parts of the spine.—Observation has shown that certain portions of the column are more frequently the seats of injury than others. Commencing from below, the parts referred to are, 1, the dorsi-lumbar; 2, the cervico-dorsal; 3, the

atlo-axial regions. It thence appears that the portions most prone to injury are those situated where a flexible joins on to a comparatively inflexible division. And it might be expected that such should be the case. A force directed upon a pliant part of the column will cause it to bend, but on reaching a more rigid part, it will fail to do so; instead, therefore, of meeting with a gradual yielding, it will encounter a dead resistance; the force will be concentrated in place of divided, and it will overcome the strength of the material. Sir C. Bell illustrated the point by the breaking of a fishing-rod. If the trout-fisher in casting a long line snaps his rod in twain, the fracture will take place, not in the centre of one of the pieces, but near a joint—that is, at a part analogous to where the spine is most liable to be broken.

Sprains.

The whole number of joints in the spine is little short of eighty; each articulation being provided with its complement of ligaments. Besides these proper ligaments, others pass from vertebra to vertebra, at numerous different points; among which the ligamenta subflava are particularly noted for their elasticity and strength. When the column is subjected to a violent bend or twist, the force comes chiefly on these joints, and their cordages; but it may reach also the intermuscular septa, fasciæ, and tendinous expansions of the muscles. If not sufficiently strong to withstand the violence, the fibres composing them will be overstretched and torn, sprained, or ruptured.

Sprains in the spine will present some diversities of character, according to the part of the column in which the force is concentrated. If it fall principally on the dorsal region, characterized by rigidity of structure, the injury will be of the nature of a jar or jolt, affecting a particular point; if it be directed either on the cervical or lumbar region, which are remarkable for their mobility and elasticity, the impulse will be broken and dispersed, and the injury more general.

Again in reference to the cervical region, it is to be noticed that sprains are liable to take place in it from a special cause. Owing to the skull being articulated at its base, near the middle, on the summit of this portion of the column, imaginary lines drawn from the point of junction to the farthest convexities of the skull along its periphery, will represent levers, which will act on the axis of motion in the cervical vertebræ, with power commensurate to their different lengths. For example, if a man falling headlong lights on the parietal convexity of one side, the portion of skull intervening between that eminence and the occipito-atlantal articulation, will be like a lever, which will propagate the force with increased power to the cervical vertebræ.

Cases of Sprains of the Neck.—The writer has lately had under his care three cases of sprain of the neck, occurring successively within a short period. As they illustrate varieties in the accident, the details may be briefly given. In two of them, symptoms of the spinal cord having been involved were present for a short time.

1. A young man, in a carpenter's workshop, was stepping backwards, when he tripped on a heap of planks, and fell on his back. His shoulders were received on the planks, but his neck and head passed beyond them; the head consequently descended with a sudden impulse towards the floor, and by that means the neck underwent an abrupt bend backwards. Swelling at the back of the neck, from the occiput to the scapulæ, so great as to be visible at a distance, took place soon after the accident. He was unable to keep his head erect; and before attempting to do so, placed a hand on each side to steady it. In twelve days, he began to sit partly up in bed, to take his meals. At the expiration of a month, having been provided with an artificial support, he was well enough to be made an out-patient.

2. A man, aged thirty-one, while engaged in amusing his infant, on the floor, and stooping on his hands and feet, was springing forward, when he tripped and rolled over, with his head under him. The weight of his body came with an impulse on his neck, and gave him much pain from the twist it caused. He lay motionless, flat on his back, for ten minutes. When he attempted to move either his arms or legs, he found himself unable: and he had a sense of numbness, and of pricking, throughout the body. His legs gave way under him, as if he were intoxicated, in trying to stand. On being brought to the hospital, it was necessary to carry him into the ward. When lying on the bed, he moved both upper and lower extremities, but in a feeble, or forced manner. Sensation was not lost, only impaired; he was able to tell correctly what parts of his body or limbs were touched. Within twelve hours, both motor power and sensation were restored; and the paralytic symptoms did not afterwards return. He complained of acute pain in the neck, which was aggravated by the slightest motion of the head; and he therefore kept the head perfectly still. He lay in bed, with his neck sunk on a low soft pillow, propped around with sand-bags. On examining the neck, the chief tenderness was at the site of the fourth cervical vertebra; and there deeply-seated swelling could be perceived. The treatment consisted principally in the enforcement of absolute rest for the neck; with the application of the tincture of iodine. A plastic shield, or support reaching from the shoulders to the back of the head, having been prepared, he was allowed in a month to leave his bed. He could then perform the nodding, but not the rotatory, motions of the neck; when trying the latter, he turned his whole body round. In nine weeks, the movements of the neck seemed to be quite restored; but he was kept in the hospital, for precaution's sake, three weeks longer. He returned to his occupation, that

of a shoemaker, and called several times subsequently to show that he was well.

3. A little girl, three years old, of slightly rickety conformation, with large head, was admitted into the hospital, late one evening, with paralysis of the upper and lower extremities. She had fallen that morning out of bed, head foremost, and was insensible for a few minutes. During the day, it was remarked that she did not get upon her feet, or move her legs; and that she did not use her hands, as in feeding herself. When examined, motor power was observed to be lost in both upper and lower extremities. She showed no signs of pain when the skin was pricked anywhere below the upper part of the chest. Reflex movements were excited in the lower extremities when the skin of the abdomen, and it alone, was pricked; and then the child gave a slight cry of pain. Respiration was natural. Neither bladder nor rectum was affected. When the head was lifted from the pillow, for the purpose of examining the neck, the child uttered cries, both, as it appeared, from the pressure of the fingers at the back of the neck, and the movement; during the proceeding, she held the head in a stiff, constrained position, and after it, seemed pleased to keep the head at perfect rest on the pillow. For three days, no perceptible change was observed in the child's condition. On the fourth, there were visible signs of improvement. On the fifth day, it was discovered that she could freely move both upper and lower extremities, and motion of the head had ceased to give her pain. The mother, who had been allowed to stay in the hospital, being impatient to return home, took the child with her, in spite of the representations made to her of the danger. But she brought the child repeatedly afterwards to be seen, and she remained quite well.

Sprains in the loins.—Sprains of the spine are more frequently in the lumbar region than elsewhere. They are generally caused by forces which bend the column downward and forward in excess. An ordinary example is that of a person falling from a height, and alighting on his nates. Owing to the body of the individual, in such a case, descending with uniformly accelerated velocity, it follows that, if the height be great, the momentum will very much increase before he reaches the ground; when he arrives there, the descent is suddenly interrupted by the contact of the nates with the ground, but as the power of inertia continues in force in the upper part of his frame, and is restrained only by the spine, that upper part descends, and expends all its momentum on the column; hence the cervical and dorsal regions, and the load with which they are weighted, fall down towards the pelvis, the body is doubled up, and a violent strain is caused on the joints of the lumbar vertebræ. A bricklayer, recklessly, and for a wager, took a leap from the top of a four-storied house, on to a heap of loose sand on the ground. He came down on his buttocks, and was found to have sustained a severe sprain in the loins. In a moderately short time he recovered from the effects of his foolhardiness. Or the loins may be sprained by a heavy weight falling on the upper part of the body, while the lower limbs are fixed: the spine is then in the position of a long lever, with the fulcrum situated at the junction of its base with the pelvis; the superadded superincumbent burden represents the force acting on the lever, and the power thus mechanically generated is centred chiefly in the loins. The direction in which the spine is thrown is generally downward and forward; hence the structures on the fore part—the bodies of the vertebræ and intervertebral substances—suffer compression; those on the back undergo elongation and overstretching.

Considerable tumefaction across the region of the loins soon follows accidents such as have been described. Ecchymosis may or may not be combined with the swelling. Sometimes discoloration does not appear for several days. The line of the spinous processes is found, on tracing them, to be normally straight, and their surfaces level. Pain on pressure, instead of being limited to the processes of one or two vertebræ, which would raise the suspicion of fracture, is the same throughout many adjoining ones equally. With difficulty, and much exhibition of weakness and pain in the loins, the patient will make an effort to hold the spine erect, and if he succeeds, and no deformity be presented, it may be assumed confidently that the injury consists only in a sprain. The posture he will prefer in bed will be that of lying on one side, with his body semiflexed, and he will be reluctant for many days to make the slightest change in his position—any slight movement exciting fugitive spasms in the lumbar muscles, analogous to those in a fractured leg. The chief criterion of his getting better is that he moves himself about in bed of his own accord. It commonly takes from four to six weeks' confinement in the recumbent position for recovery to be effected. The treatment does not differ essentially from what is followed in sprains of the joints generally. A mercurial purge may be administered at first, the diet kept low, and an occasional dose of Dover's powder be taken at night. For local applications, priority may be given to poppy fomentations; or, either as a substitute or successor, cotton-wool may be steeped and then wrung partly dry, in a lotion of lead and opium, or of arnica; when teased out, it may be laid in a thick layer, widely over the loins; if covered first with oil-silk or gutta-percha, and then with dry flannel, the wool will retain its moisture and warmth for a long time without change, and be an efficient and agreeable application. At a later stage preference may be given to a lotion containing sal-ammoniac. When the

swelling has been dispersed, and induration remains, mercurial liniment or tincture of iodine may be advantageously used. It will be proper to provide the patient, when about to leave his bed, with a riding belt stiffened by additional whalebone.

Hæmaturia, from sprain.—In cases of sprain occurring at the lumbar region, it is not uncommon for the patient to pass blood with the urine for several days after the accident. From this it may be inferred that one, or perhaps both kidneys have been injured, so that a breach of surface has been produced. When the situation of these glands in relation to the spine is considered, it need not suprise us that a complication such as hæmaturia should be met with. The kidneys lie in close contiguity to the spine at the part where the flexion of the column, on the occasion of sprain taking place, is most acute. And they are fixed to the place they occupy with comparative firmness: so as to be incapable, like the floating viscera, of evading injury. It is also to be borne in mind that, when the spine is violently bent, in the production of sprain, the flexion, at the moment, is much greater than observation could enable us to discern; for owing to the elasticity of the column, it follows that, as soon as the compressing force ceases to act, it recovers its form, by its resilience. The writer cannot refer to the evidence of post-mortem examinations for stating at what particular part of the gland the lesion from which the blood is derived is situated; but it may be conjectured that it is somewhere in the hilum. In that case, the blood will flow directly into the pelvis, and thence, along the ureter, into the bladder. The amount lost varies in different cases. Clots are occasionally formed in the bladder, requiring the injection of warm water for breaking them down. In general, the discoloration of the urine is high—deep red, or brown—only for one or two days; on the third or fourth day, the color may be clear and florid; and in a day or two more, or even in a shorter time, the water may be of its natural appearance.

Rarely is the quantity of blood lost so great as to excite alarm; yet in a case lately witnessed by the writer, apprehensions were for some days felt that the patient, a young man, would not recover. The sprain had not been severe: the bleeding was uninterrupted, and unusually profuse during the first four days; it nearly ceased for two days; then it returned, and lasted with its former profusion for two days. A cessation for a day now took place; on the following day, the tenth, it reappeared in great quantity; but it then stopped finally, the patient having become blanched and excessively weak.

When such an important gland as the kidney has been crushed and broken, to such an extent that hemorrhage goes on from a rent in it for several days, it might be thought probable that the damage would be followed by ulterior bad results, especially that inflammation—nephritis—would ensue. But extensive observation negatives that view: general experience shows that when patients recover from the immediate effects of hæmaturia brought on by sprain of the spine, they are not more prone than others to renal complaints.[1]

It is here to be remarked that, if the kidneys be previously diseased, hæmaturia may occur from a comparatively slight injury. That is well known in reference to cases in which calculi have formed in the kidneys. The remark applies also to the congested condition of the gland in the early stage of albuminuria, of which the following case is an illustration.

The writer was witness in a trial in which a gentleman claimed compensation from a railway company, for being affected with Bright's disease, in consequence of an injury to his back received in a collision on their line. The injury consisted in a bruise over the right ilium, and side of the loins. As he walked some distance for his pleasure, and took a long journey immediately afterwards, it may be inferred that the contusion was not severe. On the following day, he observed blood mixed with his urine; and he continued for four more days to pass blood. On examining the urine at that time, his medical attendants found albumen contained in it; and they particularly stated, that the quantity of albumen was larger in proportion than could be accounted for by the presence of the blood. During the whole period from the date of the accident to that of the trial, eleven months, the urine was found to contain albumen. And the view contended for by the witnesses in his favor was—that albuminuria had been caused by injury inflicted on the right kidney, in the collision. On the part of the railway company, it was ascertained that previously to the accident the gentleman had been subject to eczema; and that, shortly before it, he had been cured under treatment. Accordingly, the medical witnesses on that side (the writer being one) argued that albuminuria was known to follow eczema, on its being cured; and for that, and other reasons which need not be stated, they expressed a strong opinion that the plaintiff was suffering from the disease when he met with the accident, and that the injury could not have brought it on. The jury, nevertheless, awarded heavy damages to the sufferer.[2]

[1] In his Lectures delivered at the College of Surgeons, Mr. Le Gros Clark makes the following remark, regarding hæmaturia, as it occurs in connection with injuries of the spine: "Of the many cases I have witnessed, I have never had reason to suspect that nephritis or organic disease followed." Brit. Med. Jour., October 3, 1868.

[2] A somewhat similar case was reported briefly in the Times. A woman had been bruised in the loins, from the falling in of the roof of her dwelling. She claimed compensation for the injury, from her landlord. The

Sprains; hemorrhage in vertebral canal; paralysis.—Sprains of the spine have hitherto been considered only in reference to their effects on the joints, apart from the spinal cord. It is now proposed to attend to a class of the same injuries, in which blood becomes extravasated in the vertebral canal, the spinal cord is compressed, and paralysis ensues. The following case will serve to illustrate and introduce the subject.

A female, aged sixty, was admitted into the Middlesex Hospital under the writer's care, in March, 1841. She had fallen down a flight of steps shortly before. Her back was the part principally injured; but no irregularity in the line of the spine could be perceived; and although she sat up for examination, there was no particular part at which she felt greater weakness than in others. Both upper extremities, and the right lower extremity, were deprived of voluntary motion. Sensation, however, was nearly perfect in these members; she spoke only of a little numbness in them. Reflex movements could not be excited in the upper extremities; but they were particularly lively in the paralyzed lower extremity. Very slight causes brought them on. For example, if she spoke loudly, or if she sneezed, the leg would spring up; bending the knee, and tossing the bed-clothes up. And she was evidently alarmed at these unaccustomed movements. Being of a quick temper, and especially grieved at her hands not obeying her will, she not unfrequently gave way to violent passion; on these occasions, she would shake her head vehemently, and utter lamentations at the top of her voice; whilst thus exclaiming, the leg, over which she had no control, would suddenly jump up, and that instantly silenced her. The rolling of the head here adverted to, was an additional proof that the bones and articulations of the upper part, at least, of the spine, were not seriously injured. The breathing was not disturbed, as might be inferred from the loudness of her voice referred to. At first, she had retention of urine; and for a few days, incontinence; but she soon afterwards had natural control over the bladder. The action of the bowels was regular. During the first ten days, no perceptible change took place; but in the following fortnight, a slow and gradual increase of power over the paralyzed limbs was observed. After that, all progress seemed to cease. There being no weakness or pain in the spine to interfere with getting up, she did not remain long confined to bed, and soon made attempts to walk. In these, it was necessary that she should be assisted by a nurse on each side; as owing to the paralysis of the arms, she was unable to use crutches. Each time the paralyzed (right) leg was lifted from the ground and advanced, it described a gyration in the air; and it was too weak for her to bear her weight upon it. The way in which the muscles of the upper extremities regained some of their power was peculiar; being different in each. On the right side, the muscles of the upper arm became stronger, but no improvement took place in those of the forearm; it was the converse on the left side; the muscles of the forearm became stronger, but no improvement took place in those of the upper arm. Consequently, on the right side, the patient was able to bend and extend the arm at the elbow, but she was unable to hold anything in her hand; while on the left side, she was able to close the fingers and hold an object, but she could not bend and extend the arm at the elbow. Accordingly, she contrived to make the one supply the wants of the other. Thus, when she wished to take anything into the left hand, she employed the right arm to lift it to a proper level, or to guide it according to her wishes. She was kept in the hospital for three months, long after every hope of amendment had been abandoned. The subsequent history of the case is not known.

In seeking to account for the paralysis in the above case, the idea of its having been caused by fracture or dislocation of the spine, may be dismissed. Had either given rise to it, the patient could not have sat upright; there would have been irregularity in the line of the spine; the paralysis would have included both lower extremities; and motor power and sensation would probably have been lost conjointly.

The next view is, that a bloodvessel had been ruptured by the violence; and that the blood had been extravasated into the vertebral canal, compressing the spinal cord, and partially depriving it of its functions.

That, in this case, the blood which escaped had been poured into the loose space intervening between the osseous walls of the canal and the theca spinalis, seems most probable; and also, that the source of the blood was the venous sinuses, which line the interior of the canal in the form of plexuses. It is to be noted that in these capacious sinuses there are no valves; and that if one branch of the plexuses be ruptured, the blood will flow unobstructed from all indiscriminately. It is likewise to be observed that the sinuses are subject to the influence of the acts of respiration: they will be nearly empty, in inspiration; but overdistended and ready to burst in expiration. When a person, therefore, meets with an accident, such as that of falling downstairs, and some part of the spine, most likely the cervical, is inordinately bent or twisted, it may be understood that a particular branch of the venous plexuses lying in close proximity to the bony surface of the vertebral canal, where the flexion is most acute, will be liable to be squeezed and torn. Again, owing to the bend of the neck referred to, together with a doubling up of the body, and compression of the chest in the fall, the breathing will be interrupted, or the act will be that of expiration; and as it is during expiration that the venous sinuses become overfilled with blood, and their coats overstretched, it may be understood that the danger of rupture taking place will be increased from that cause.

As the paralysis was partial, three alone out of the four extremities being affected, and motor power being the only property lost, it may be inferred that, if the blood extravasated external to the theca were the compressing agent, it had been collected in the canal in unequal quantities at different parts. Such an hypothesis would explain how one of the lower

medical witnesses on her side gave evidence to the effect that she was seriously ill from Bright's disease, and that the disease was the result of the accident she had sustained.

extremities escaped being deprived of its motor power: for it may be supposed that a smaller quantity of blood had been deposited at the part of the cord with which the nerves of that extremity communicate than elsewhere. In regard to the other point, namely, that sensation was preserved while motion was lost, it is a fact generally observed in affections of the spinal cord, that motor power is frequently destroyed while sensation is not affected. No more frequent example can be referred to than the paralysis which attends caries of the vertebræ; for in these cases sensation is rarely lost. And the difference, it would appear, depends on the seat of sensation in the cord being placed more deeply and securely than that of motion, so that a compressing force, or morbid influence, reaches the latter sooner than the former. Hence it may be understood, that if in this case a clot of blood were the cause of the compression, the power of motion might be lost, independently of sensation.

In the narrative it is stated that little or no amendment in the paralytic symptoms was observed during the first ten days, that in the following fortnight the affected limbs increased perceptibly in strength, but that afterwards improvement ceased. These phenomena may be explained on the supposition that the blood in contact with the spinal sheath did not undergo, for some time, any material change; that absorption of the fluid constituents of the blood somewhat later took place; and that then, from the cord being partly relieved of compression, there was a proportionate addition to the strength; but that, at last, no further reduction in the size of the clots could be effected—that the coagula, at one time like jelly, had become indurated and adherent.

A question in connection with these cases of intravertebral hemorrhage originating in injury, of great interest, but difficult to answer, is this: Can it be ascertained during life, from appropriate symptoms, whether the effused blood has been derived from a torn vessel without or within the theca—that is, whether the blood is situated outside or inside the sheath of the cord? In the case just related it has been considered that the extravasated blood was situated between the theca and the osseous wall of the canal; but as there was no post-mortem examination to verify the opinion, the conclusion must be taken as uncertain. And the difficulty of replying to the question arises from the circumstance here indicated, the dearth of well-observed cases completed by including an account of the appearances after death.

In treating of the subject, Mr. Le Gros Clark says: "Extravasation of blood within the theca vertebralis may occur without fracture; but such instances affording an opportunity of verifying the actual condition are rare. I have a memorandum of a remarkable case of this kind, which was narrated to me, but which I did not see. A man was struck violently on the back with a chain-cable; there were no immediate symptoms of spinal injury, but a paraplegic condition soon supervened, extending rapidly upwards, and destroying life by asphyxia. The theca was found distended with fluid blood, derived from a ruptured spinal artery."

He refers to another case: "A man was injured in a collision in the tunnel, four or five miles from Brighton. He walked this distance with some difficulty into the town, and within twenty hours became entirely paraplegic. He recovered slowly; and after a lapse of two years, was able to walk as well as before the accident. One spot on the back was always tender, and continued so still at times. The analogy between this case, and the similar but fatal injury which I have already mentioned, seems to point to hemorrhage as the probable cause of the protracted symptoms."[1]

Inflammation of joints of the spine from sprain.—One of the dangers to be apprehended from a sprain in the spine is that inflammation will spread from the joints, the first recipients of the injury, to the adjacent structures, and thus involve the spinal cord.

The observations about to be made do not apply to caries of the vertebræ; a disease in which the cord is frequently included, and paraplegia the result. Patients who have that complaint, or their friends, generally attribute its commencement to a fall or blow on the back. But when the history is properly investigated, it is commonly made out satisfactorily that the morbid process had begun before the accident, and that the injury only aggravated and made apparent a latent disease. See DISEASES OF THE SPINE.

The subject now entered on is not altogether easy to treat. And a principal difficulty arises from the circumstance that in accidents which are apparently alike, the events are greatly varied. Thus it has been already seen that, in sprains of an apparently alarming severity, in which it was evident from the symptoms that the cord had participated in the injury, none of the serious results which might have been expected followed (Case 2, p. 789). On the other hand, cases may be met with occasionally, in which the original violence has been comparatively slight, and disastrous consequences have unexpectedly ensued.

The joints implicated in a sprain are liable to be affected with chronic inflammation, and what is then chiefly to be apprehended is, that the products will gain access to the vertebral canal, and so lead to destruction of the functions of the spinal cord. In con-

[1] Lectures at the College of Surgeons, reported in Brit. Med. Journ., October 3, 1868.

In the London Hospital Reports two cases are related, with interesting details, of incomplete paraplegia from injury of the spine, in both of which the patients recovered. As the men were able to sit up, and attempt to walk, each within a few days from the accident, it may be inferred that there was no breach in the vertebral column in either: and that the symptoms depended on intravertebral hemorrhage. Vol. iii., pp. 334, 336.

nection with this, it may be noted that an important distinction exists between the relation of the dura mater of the brain to the cranium, as contrasted with the relation of the theca, or dura mater of the spinal cord, to the inside of the vertebral canal. In the former, the membrane being firmly adherent to the bone, serves the purpose of periosteum: whence, if the cranium be injured or diseased, the dura mater will become inflamed, and the inflammation will extend immediately to the brain. But in the latter, the bony structures of the walls of the canal have a distinct and appropriate periosteum; the dura mater investing the cord is at a remote distance from them. Consequently there is not the same danger of inflammation, set up in the parietes of the canal, spreading to the cord, as in the case of the brain.

When joints of the spine that have been damaged by sprain are attacked by chronic inflammation, they are liable to follow a course, first, of gradual swelling and induration, and then of indolent suppuration, like what takes place in other joints. The earliest symptoms in these cases of nerve-affections may be partial paralysis, depending on some of the spinal nerves, which come out from the canal at the seat of disease, and are involved in their passage through the intervertebral foramen in the abscess, being deprived of their functions. Later, the paralysis may be more general, including the lower and perhaps also the upper extremities, thereby showing that the cord has become compressed by intrusion of a portion of the abscess into the vertebral canal; in these circumstances irregularities and inequalities in regard to the functions lost or retained in the afflicted limbs, will be observed. At this stage, when chronic abscesses surround the diseased vertebræ, and there is accompanying paralysis, the question may arise whether the case be not one of caries of the spine. Doubt on that point will be removed when it is perceived that there is an absence of angular deformity at the seat of disease. In caries of the vertebræ, it is invariably the bodies and intervertebral substances which are destroyed; and as the destruction of these parts is in fact an undermining of the superior portion of the pillar, that portion necessarily falls forward. By so doing, a prominent bend in the line of the spinous processes is produced, but such an angle is not formed, however much the lateral articulations are destroyed. When the abscesses break, and continue discharging pus, the prognosis is unfavorable. But if they be arrested while immature, anchylosis of the diseased articulations may take place; absolute rest will then be gained; resolution of the abscesses may be effected, and from compression on the cord being removed, its functions may be restored, and the patient will recover.[1]

Latent breach of spine from sprain; suppuration in canal; subsequent paralysis.—This is not an unfit place to introduce a notice of certain injuries of the cervical region of the spine, which may be exaggerated examples of sprain. They are distinguished by a breach having occurred in the column, and on that account they might be treated in connection with fractures. But the violence causing the breach resembles that by which sprain is produced; the vertebræ by their elasticity recover their places, the injured part can still support the weight of the head erect: paralysis occurs, not, however, from the direct effects of the original injury—it supervenes, several days after the accident, from suppuration in the canal, the consequence of the lesion.

The breach may be presented in two different forms: either as the effect of a rupture of the connecting ligaments of two adjoining vertebræ, in which the articulating surfaces have first been divorced, and then have settled down again into their places; or, as a horizontal fissure across the middle of one of the vertebræ. In both instances it may be understood that, when the disrupted portions have come back into apposition, they will be retained *in situ* by the surrounding muscles.

A case which illustrates the first kind of accident has been recorded by Sir C. Bell. A man fell from the shaft of his wagon, and pitched on the back of his neck and shoulders, where swelling and discoloration soon afterwards appeared. He complained of stiffness in the back of his neck; on account of which, leeches were applied. On the eighth day, he was seized with a succession of convulsions, which lasted twelve hours; and the struggles in his delirium were so violent that it required two men to hold him. The delirium continued with interruptions. On the twelfth day, he lost power over one arm; two days later, he was paralyzed in the lower extremities, but he regained the command over the arm; on the eighteenth sensation returned in the lower extremities; on the following day, he died. It was discovered, on dissection, that there was a loosening of the connections of the seventh cervical vertebra with the first dorsal; and between them there was a considerable space, the intervertebral substance having been destroyed. On cutting the muscles at the side of the last cervical vertebra, a little pus oozed out from between the bones. Within the spi-

[1] An interesting case of partial paralysis, arising from injury to the cervical vertebræ, and presenting numerous different phases in its course, is related under the head of Twists of the Spine, by Mr. Erichsen. It appears from the account of the condition of the neck, and from the symptoms, to have been a case of the kind described in the text. The patient recovered. On Railway Injuries: by John E. Erichsen, p. 86.

nal canal, pus was found to have dropped down through the whole length of the sheath, to the cauda equina. Outside the spine, pus lay under the scapulæ; in front, it was bounded by the œsophagus.[1]

Mr. Simon has furnished a case which illustrates the second form of the injury. It is given under the title, "Latent Fracture of the Spine proving fatal by Suppuration within the Vertebral Canal." The details are briefly these. A girl, in the dark, fell down an embankment, twelve feet high, and injured her neck. She afterwards walked three miles. For eleven days she continued at her occupation. On the fifteenth, she applied for admission into St. Thomas's Hospital, on account of severe pain in her neck. No irregularity in the spine could be detected. There was no anæsthesia or paralysis. Her complaints of pain and tenderness were vague; she spoke chiefly of suffering between the shoulders; and turning round into the prone position in bed was done slowly, stiffly, and with cries. Early on the following day she complained of numbness and twitching in her limbs, especially in the lower; and in the evening, voluntary motion was quite lost in the legs, and almost in the arms; sensation also was very much impaired in both. High fever, with delirium and tympanic distension of the abdomen, accompanied the last-mentioned symptoms. She died on the third day after admission, or eighteenth after the fall.

"On examination thirty hours after death, a horizontal line of fracture was found traversing the body of the seventh cervical vertebra, just above its inferior surface. Beyond a very little gaping in front, which would allow the edge of a scalpel to be insinuated flatly between the fragments, there was not the slightest displacement; and the posterior common ligament was untorn. The vertebral canal contained between its osseous walls and the dura mater a large quantity of pus, which, from two inches below the foramen magnum, descended the whole length of the cord. At the several intervertebral holes, it had crept somewhat along the issuing nerve-sheaths, and between the first and second dorsal vertebra had actually emerged, following the subdivision of the first dorsal nerve, so as to spread among exterior parts. These burrowings of matter were cut into before the canal was opened. . . . The outer surface of the dura mater was roughened by inflammatory deposits; but none were found within it; nor was there any softening, or microscopical change in the structure of the spinal cord. No other disease was discovered in the body."[2]

Concussion of the spinal cord.—High authority sanctions the use of the term "concussion" of the spinal cord, to indicate an injury of the back, followed by paraplegia.[1]

The word is intended to express a certain effect produced upon the cord by violence, which reaches it directly. The injuries that have hitherto engaged our attention have arrived at the cord indirectly; that is, the functions have been destroyed or impaired through injuries which have originated in structures adjoining, but external to, the spinal sheath. In concussion, the inmost recess is penetrated at once, and the organic changes connected with the cord commence and finish within the sheath. That sheath, continuous with the cerebral dura mater, forms along with it the boundary of the large cavity that contains both brain and spinal cord. Accordingly, there is this difference between the first class of injuries and concussion, namely: that in the former the sheath or dura mater of the spine forms a defensive barrier, more or less effectual, between the primarily-injured structures and the cavity common to the brain and cord; while in concussion, the morbid processes are conducted from first to last in the interior of that cavity.

The term "concussion," as applied to the spinal cord, has obviously been derived from a supposed analogy between the injuries occurring to it and to its kindred organ the brain. When a man's skull is beaten in and a fragment is depressed, or when a torn artery throws out blood which coagulates and produces pressure on the brain, paralysis of one side of the body ensues; the surgeon elevates the depressed fragment, or exposes and washes away the coagulum, and forthwith, in favorable cases, the paralysis disappears. So when the spine is fractured, and displacement of the fragments takes place, the end of one of the portions presses upon the cord, and it is conceived that the paraplegia resulting from the accident must be owing to that compression. But certain cases of injury of the back are met with in which paraplegia has directly or shortly afterwards occurred, and in which, upon examination of the spine after death, no fracture, displacement, extravasated blood, or anything capable of compressing the cord, can be be discovered. The explanation therefore given is, that the spinal cord had been damaged by concussion.

The following case has been just recently reported in one of the journals.

A man fell from a railway van, and lighted

[1] Surgical Observations, p. 145.

[2] Trans. Pathol. Soc., vol. vi., p. 42.

Further on, a case will be noticed in which the atlas has been fractured transversely near its middle, and in which the anterior segment, including the articular surfaces in relation to the occiput and the atlas, and carrying off with it the processus dentatus of the axis, had been dislocated extensively forward; no suppuration, and no paralysis followed; the patient lived about a twelvemonth. During life, the nature of the injury was unsuspected; it might well have been taken for sprain.

[1] Treatise on Dislocations and Fractures, by Sir A. Cooper; edited by Mr. B. Cooper, p. 526.

"Concussion of the spine," often used, is objectionable as a title. We do not speak of the concussion of the skull.

on his head and shoulders. Instant paralysis of both upper and lower extremities was the consequence; and the breathing was diaphragmatic. He lived only for about sixty hours. On examination, neither fracture nor dislocation was found in any part of the spine; nor was blood effused in the canal. But on making a section of the cord, opposite the third and fourth cervical vertebræ, a clot of blood was found lying in its centre.[1]

From the remarks appended to the case by the narrator, it is obvious that he had no doubt of its having been a case of concussion, and it would seem that the same opinion would be held generally. But it is evident that the lesion in the cord admitted of being satisfactorily accounted for otherwise. It does not appear improbable that a sudden, violent, and extreme bend or twist of the flexible cervical region of the spine, should have been caused by a fall headlong from a height; or that, with that excessive bending of the spine, the cervical enlargement of the cord should have been bent likewise; or that in that sharp, acute, abrupt flexion of the cord, a bloodvessel should have been ruptured in its interior, and a clot of blood be deposited. In two of the cases mentioned on p. 789, under the head of Sprains of the Neck, the violence of the bend or jolt could not have been so great as in the supposed case of concussion now referred to; yet from the paralytic symptoms immediately attending the injuries in both, it was clear that the cord had been damaged, though slightly and transiently. It may be inferred, therefore, that the accidents were essentially alike, though the lesion and its effects in the one, were much severer than in the others.

The question of "concussion of the spinal cord," and of its phenomena generally, has excited more lively interest in the minds of surgeons, and even among the public generally of late years, than formerly; and that has obviously arisen from the frequent occasions in which it is prominently brought forward, in courts of justice, as the source of numerous formidable evils that result from accidents in railway collisions.[2] It is important, therefore, to endeavor to understand the precise nature of the injury so designated.

Why the term "concussion" should have been applied to an injury of the brain, is not difficult to comprehend; but the same cannot be said in reference to the spinal cord.

As the cranium is a hollow sphere, the parietes of which are dense and elastic, it may be readily understood that, if smartly struck at any part, the blow will cause a vibration to run through its walls in every direction. The vibration may travel in some of these lines of direction more readily than in others; but as no *dampers* are interposed anywhere, the shake, or concussion, will be general. Again, the brain completely fills the cranial cavity, fitting closely into all the hollows and sinuosities. But from being of a pulpy or doughy consistence, and withal inelastic, it is incapable of vibrating in harmony with the bony case surrounding it. Hence, when the skull is set vibrating, it is obvious that the vibrations will inflict a succession of blows on the brain. These will vary in force in different cases, but they will follow in rapid sequence; and the multiplication of them, even when comparatively weak, will be injurious to the delicate textures of the brain.

In the vertebral column, on the other hand, the structure both of the containing and contained parts is of an entirely different character. The spine is a long, flexible, tubular cylinder, divided into numerous segments. Between each two bones, a damper, in the form of an intervertebral substance, is inserted; and the layers of muscles clothing the spine also intercept vibrations. Again, instead of the spinal cord being in direct apposition to the osseous walls of the vertebral canal, like the brain in relation to the cranium, it occupies the centre of that roomy chamber, and is at a considerable distance from them. Moreover, except at the foramen magnum, the dura mater of the cord (theca) has no attachments to the sides of the canal but what it forms at the intervertebral foramina, through the sheaths of the spinal nerves; and it invests the cord quite loosely in its whole length. Accordingly, even if the spine did vibrate, there would be no connecting medium capable of conducting the vibrations to the cord.

Hence it may be seen that the effect of an injury to the head, as relates to the brain, differs from that of an injury to the spine, as relates to the cord. In the one, the skull undergoes a general shake, and the brain is correspondingly concussed. In the other, the violence falls with principal severity on the most flexible, weak, or exposed part of the spine, according to the direction it takes; and the damage to the cord is local, contrasted with general.

Applying these observations to the effects produced on the nervous system by the injuries chiefly characteristic of serious railway accidents, it does not appear that the term "concussion of the spine," so often used in connection with them, has been well chosen. It ought to have been of more comprehensive signification. When a per-

[1] Brit. Med. Jour., April 24, 1869.

[2] The total sum paid, in 1867, as compensation for personal injuries, by the railway companies of the kingdom, was £347,000. One company alone paid 86,000*l*. The number of travellers, that year, was 287,000,000; of killed 19; of injured 638. (Newspaper paragraph.)

son is involved in a dangerous railway collision—in which the train, pursuing its lightning course, has been instantly arrested—the whole body is in a concussion. If any part deserves to be singled out from the rest as especially exposed to have its functions greatly deranged, it will be the brain. The neck of a man represents a stem on which the head is placed; and is a particularly flexible stem for so great a weight to be put upon it. Accordingly, when the train's career is suddenly stopped, and the carriages bound and rebound, and jump up, and fall again, the head is beyond the patient's power of controlling—it swings in different directions, and is painfully jerked to and fro. He may have escaped actual concussion of the brain; there may not even be found a bruise upon his head; and after a little time—spent, it may be supposed, in the circulation becoming restored to its equilibrium—he may be able to "shake himself up," walk about, and resume his journey. Yet no one will be surprised to find that lasting injurious effects have been produced on his brain by the accident. But the head, and the cervical portion of the spine concerned with it, are not the only parts that require additional mention. It cannot be forgotten that the viscera both of the thorax and abdomen partake each more or less the character of "floating;" that they are suspended at their roots by ligaments, or their equivalents; and that within the folds of the serous membranes which form these connections, not only bloodvessels and absorbents, but nerves, particularly of the sympathetic system, are inclosed. When the body is jolted, jarred, and shaken, in the violent manner described above, it is self-evident that the viscera will be stirred and jolted likewise; that their internal structure will be subject to be bruised or lacerated, giving rise to ecchymosis; and that the nerves on their passage may be stretched, torn, or otherwise injured. Thus all the great constituent parts of the nervous system—brain, spinal cord, and sympathetic system—are included in the common risk of the catastrophe. And the account would be incomplete, if the influences of the mental shock—that of fright and of witnessing appalling spectacles—were neglected.[1]

Progressive paraplegia; chronic degeneration of cord; resulting from injury of the spine.—A chronic disease of the spinal cord, which ends in partial destruction of its substance by degeneration, and during its gradual course is attended by slowly progressive paraplegia, has long been known as an idiopathic affection. Of late years, the same disease has been represented as a sequel of what is called "concussion of the spine." It has therefore a claim to be considered in this place.

The most eligible way, it appears, of treating this subject will be to illustrate the disease and its phenomena by the narrative of a properly completed case; that is, one in which an account of the post-mortem appearances is included. Cases of that kind are singularly rare. In the newspapers, one reads almost daily of persons being brought into courts of justice—lamentable spectacles, lying in litters, at the threshold of death's gate—plaintiffs claiming pecuniary compensation for personal injuries in railway collisions. But the number of deaths among such persons must be few; otherwise it cannot be understood how the scarcity should be so great of cases in which the results of dissections have been reported. One complete case alone, of that kind, is known to the writer. It is that of a patient who had been under the care of Mr. Gore, of Bath; but whose case was related originally by Dr. J. Lockhart Clarke, to whom the spinal cord had been sent for examination.[1] The case was afterwards introduced, with additional details, into his work on Railway Injuries, by Mr. Erichsen.[2] Lastly, Mr. Le Gros Clark has published an account of it, illustrated by a woodcut, in his lectures at the College of Surgeons.[3]

In the account of the case which follows, the writer has availed himself of the descriptions given by the different authors just named. But it has to be premised that, as the patient did not come under Mr. Gore's observation till a year had expired from the accident, and then visited him only at intervals, the early history especially is imperfect.

A gentleman, aged forty-eight, met with a shock in a railway collision, but he received no wound or bruise; and only complained of a pain in his back; he walked from the train to a station close at hand. Being a man of active habits, he made every effort to get about in his business; and did so for a short time, though with much distress. Numbness and a want of power in the lower limbs gradually came on, and he became disabled; but the pre-

[1] See a series of valuable communications, "On Cases of Injury from Railway Accidents—their influence upon the Nervous System, and results;" by Dr. Buzzard. Lancet, vol. i., 1867, p. 389.

[1] See "Report on a Specimen of Disease of the Brain and Spinal Cord, consequent on a Railway Collision;" by Dr. J. Lockhart Clarke. Trans. Pathol. Soc., vol. xvii., p. 20.

[2] "The only case on record with which I am acquainted, in which a post-mortem examination has been made of a person who had actually died from the remote effects of concussion of the spine from a railway collision, is one that has very recently been related, and parts exhibited to the Pathological Society by Dr. Lockhart Clarke." On Railway Injuries, p. 113.

[3] British Medical Journal, October 3, 1868.

cise time when the paralytic symptoms appeared could not be stated, it being known only that it was less than a year from the time of the occurrence of the accident. He had previously suffered vaguely with pains down the back and in the head, though not of a very acute kind. There was great sensitiveness to external impressions, so that a shock against a table caused distress. He gradually, though very slowly, failed in every respect as to mind and body—not however losing his intellect. He became unable to walk with steadiness and firmness; the semi-paralytic state was somewhat like that of partial intoxication; but there was little, if any, jerking or twitching. Before his death, which was clearly hastened (say three months), by an accidental fall, he could barely walk with the aid of two sticks; and he was for the last month confined to bed. In the latter part of his illness, some weakness of the upper extremities became apparent; so that, if the patient was off his guard, a glass would slip from his fingers. There was not any marked rigidity of the spine, or convulsive movements. Until about eighteen months before his death, there was no paralysis of the sphincter of the bladder; then the urine became pale and alkaline, with muco-purulent deposits. He lived after the accident three and a half years.

In the brain, there was general, but slight opacity of the arachnoid membrane, and subarachnoid effusion. The cortical substance was soft and pallid, particularly at the inferior surfaces of the anterior lobes. Dr. Clarke's report of his examination of the spinal cord is as follows: "I found," he says, "that the membranes of some parts were thickened, and adherent at others to the surface of the white columns. In the cord itself, one of the most striking changes consisted in a diminution of the antero-posterior diameter, which, in many places, was not more than equal to half the transverse. This was particularly the case in the upper portion of the cervical enlargement, where the cord was consequently much flattened from behind forward. On making sections I was surprised to find that of all the *white* columns, the *posterior* were exclusively the seat of disease. These columns were darker, browner, denser, and more opaque than the antero-lateral; and when they were examined, both transversely and longitudinally, in thin preparations under the microscope, this appearance was found to be due to a multitude of compound granular corpuscles and isolated granules, and to an exuberance of wavy fibrous tissue, disposed in a longitudinal direction. It was very evident that many of the nerve-fibres had been replaced by this tissue; and that at certain spots or tracts, which were more transparent than others, especially along the sides of the posterior median fissures, they had wholly disappeared. Corpora amylacea, also, were thickly interspersed through the same columns; particularly near the central line. The extremities of the posterior horns contained an abundance of isolated granules, like those in the columns; and in some sections, the transverse commissure was somewhat damaged by disintegration. The anterior cornua were decidedly smaller than natural, and altered in shape, but no change in structure was observed."[1]

[1] An interesting point is omitted in the case; it is not stated whether the patient retained sensation through his whole illness, or not. In 1840, a case of idiopathic progressive paraplegia was communicated to the Medico-Chirurgical Society, by Mr. Stanley; in which the most remarkable morbid change found on dissection, was disorganization of the posterior columns of the cord. Shortly afterwards, Dr. Webster communicated a case in which the same morbid condition was discovered. In the first case, a period of three, and in the second, one of two and a quarter years elapsed, before the loss of power in the limbs was complete. But in neither was sensation destroyed. And the principal object of both authors was to direct attention to the latter point; as it was then thought to be at variance with the generally received opinions of physiologists, namely, that sensation was the property of the posterior columns. Six years before the first communication, Sir Charles Bell had shown that sensation did not depend on those, but on the lateral columns, of the cord; and that view has been abundantly confirmed by subsequent researches. Phil. Trans., 1834–1835.

The first remark which the reading of the above case suggests, is concerning the disproportion that appears between the slight injury sustained by the patient and the magnitude of the results, occupying three and a half years in coming to an end. From progressive paraplegia, and a morbid condition of the spinal cord, identical with what have been described in the case, being known to originate independently of injury of any kind, the question forces itself upon us—was the shock in the railway accident, a cause, or a coincidence? This doubt would not have been expressed if Mr. Gore had been in attendance on the gentleman at first; but, according to the narrative, he did not see him till a year after the accident.

But granting for argument's sake, that a shock, analogous to concussion of the brain, had really been received, the question may be asked: how would that assist in accounting for the peculiar morbid change found in the cord, on dissection? The concussion would be followed by inflammation. But that inflammation would be general: it would extend over the whole surface, and enter into the deep structures of the cord, including every column equally. The organic change, however, is not general, but partial: it is confined to the posterior columns. How, then, is that selection or limitation to be explained?

Another objection presents itself. According to modern views of pathology, the morbid action concerned in producing granular degeneration of the tissues is distinct from inflammation. The process is seen in operation in fatty degeneration of the muscular substance of the heart, in the formation of the arcus senilis, in the production of atheroma in the arteries, etc.; and in none of these instances is the degen-

eration preceded by inflammation. It may be argued, therefore, that the organic changes in the columns of the spinal cord, consisting of degeneration of the nerve-fibres, depend on some cause, not hitherto ascertained, different from inflammation; and that accordingly their connection with concussion of the cord is merely hypothetical.

On the whole, it may be affirmed, that what is most wanted for the better understanding of those cases commonly known under the title of "concussion of the spine," is a greatly enlarged number of post-mortem examinations. Hitherto our experience has been derived almost wholly from litigated cases, deformed by contradictory statements and opinions; and the verdicts of juries have stood in the place of post-mortem reports.[1]

Fracture of dorsal spine; paraplegia; recovery. Relapse in thirteen years as progressive paraplegia. Death in five years. —The following case, in its principal circumstances, is singular; it is introduced here as bearing on the subject of "progressive paraplegia," connected with injury.

H. P., aged forty-four, a shoemaker, was admitted into the Middlesex Hospital, under the writer's care, in May, 1849, with paraplegia, and bed-sores. Twenty years before he had fallen from a second-floor window in Edinburgh, and was carried insensible to the Infirmary. On the following day consciousness returned; and he then found that his back had been broken near the middle, and that he had lost the power of motion and sensation in both lower extremities. Blood in clots was mixed with the urine; and the bladder had to be washed out with warm water. He began in two months to void his urine without assistance, and to regain some power over his limbs. Issues were applied near the seat of injury. In four months, having recovered the power of walking, he was discharged from the Infirmary, and shortly afterwards returned to his work. The only remains of the paralysis at that time was defective sensation in a small part of the right leg. During the seven years following, he was uninterruptedly well, and led an active life—occasionally travelling abroad on business. He then had a fever, which he ascribed to catching cold on a diligence. Twelve months afterwards, he had pain at the seat of injury in the back; and the surgeon who had attended him formerly advised him to renew the issues there. Again, for five years, he remained in perfectly good health. It being now thirteen years since he met with the accident, a serious change in his condition commenced. His legs then began to be weak under him; and he dragged them heavily as he walked. The feebleness of the limbs gradually and slowly increased; so that having been able, at first, to get about with one, he was soon obliged to use two sticks, and afterwards crutches. In five years, he was so incapacitated that he took to his bed, and remained there for two years before his admission. When bed-ridden, both motor power and sensation were quite lost in the lower extremities; he was unable to retain either the fæces or urine; and extensive sores formed on the hips. During the whole progress of the paralysis, his lower limbs were frequently disturbed with convulsive startings, brought on without perceptible cause; and for the last six months, the legs were closely bent on the thighs, and the knees drawn up to the abdomen.

His admission into the hospital was twenty years after the fracture of the spine, and seven after the relapse, or commencement of the progressive paraplegia. A slight incurvation of the column forward, and faint indication of an angle about the fifth or sixth dorsal vertebra were observed; but, owing perhaps to an œdematous condition of the skin generally, no unevenness in the spinous, or other processes could be detected. He did not complain of pain, and bore strong pressure and percussion along the column without suffering. Paralysis was complete in all the parts below the level of the umbilicus, both as to motor power and sensation. As stated before, his legs were rigidly bent and the knees drawn close to the body, and he had no voluntary power whatever in them; but they were subject to slight reflex actions. Sensation was absolutely lost; but a source of deception was observed; that is, when blindfolded, and one of his legs was pricked, he was able to distinguish which was touched; it was found, however, that this was owing to the leg experimented on starting each time, and communicating a jar to the corresponding side of his body. There was incessant dribbling of the urine, and the fæces passed involuntarily. An extensive sore was situated over the sacrum, a portion of which was denuded and black; and there were sores likewise over the ischia and trochanters; in all, the surfaces were foul and sloughy, and of great depth; but quite painless, as shown by the patient being unconscious when strong caustics were applied.

By giving generous diet, with abundant stimulants, assisted by quinine and opium, the patient, who had been in a reduced condition, rapidly gained considerable strength. He was put upon a water-bed at first, and latterly on a spring-bed. The dressing to the bed-sores was chiefly balsam of Peru. It was an interesting fact that the deeply excavated sores soon lost their foul surfaces, threw out laudable pus, became filled with healthy granulations, and

[1] There has been recently communicated to the Medico-Chirurgical Society, a case of concussion-lesion. A man fell from the top of a hay-rick, and had partial paraplegia, loss of motor power, without that of sensation. He lived six months. On his death, the medulla oblongata and spinal cord were examined under the microscope. Extensive granular degeneration was chiefly found; the structural changes by which are represented in twenty-one figures. It is remarkable that, notwithstanding the great amount of disorganization, the patient gradually recovered the power over some of the limbs that had been paralyzed, and he retained sensation unimpaired to the last. The case was, therefore, not one of "progressive paraplegia," to be referred to in the text. "On a Case of Concussion-Lesion, with extensive Secondary Degeneration of Spinal Cord, followed by general Muscular Atrophy;" by H. Charlton Bastian, M.A., M.D., Lond. Med.-Chir. Trans., vol. l., p. 499.

cicatrized on a level with the surrounding skin, as quickly as was ever witnessed in patients of the soundest constitution. The only part where the process of skinning failed was at the centre of the sacrum, where the bone was bare. The bowels were habitually costive; and when that state lasted for some time, he felt oppressed in his breathing. He lived for eight months. As his end approached, he was subject to profuse perspirations; and a singular circumstance was observed concerning them, namely, that the paralyzed parts were not included: the hair of his head would be wet, as if it had been in the sea; large drops of sweat would be upon his face; and his shirt would be drenched, as if just out of the wash-tub; yet no sign of moisture would be visible on his lower extremities, or anywhere below the line of the umbilicus. His death was marked only by symptoms of extreme exhaustion.

Post-mortem appearances.—Fracture was discovered to have taken place in the fifth dorsal vertebra; but the union of the fragments was so compact, or the surfaces so much fused together, that the lines denoting the original breach were indistinct, and the fact was made out chiefly by observing the relative displacements. The direction of the fracture, then, was through the body, between its upper and middle thirds; and backwardly, through the arch, and upper articulating processes; the superior fragment had been slightly thrown forward and downward upon the inferior, so that a moderate bend, and an inclination to the left, were the consequences. The fourth vertebra had become united, by anchylosis, to the upper surface of the superior fragment; and the junction was so close, that the bodies were fused, and the intervertebral foramina obliterated. The sixth vertebra was not united directly to the inferior fragment; but bony outgrowths had been thrown out in front of the respective bodies, like buttresses, as if to give additional strength at the angle of fracture; and two adjacent ribs were united, on the right side, near their articulations, close to the seat of fracture. The vertebral canal partook of the incurvation caused by the displacement of the fragments; but its capacity was normal, and the surfaces even; a thin, dense, osseous plate took the place of the posterior longitudinal ligament, and lined the backs of the bodies of the vertebræ, including the intervals occupied by the intervertebral substances, so as to make a continuous smooth surface.

The spinal cord and sheath together were visibly collapsed, at the seat of fracture, both as compared with the magnitude of the canal, and the size of the cord above and below. For an inch, some soft, apparently fibrous matter, surrounded the sheath on the outside, without adhering to the walls of the canal. A portion of the cord, about two and a half inches in length, was so much disintegrated that its form and color were lost; and a friable, granular material, easily broken down, and amorphous in appearance, took the place of the healthy structure. The same morbid matter was the medium of adhesion between the remnants of the cord and the meninges. The continuity of the upper with the lower portions of the cord was preserved, as it appeared, entirely by pia mater and connective tissue; there being no vestige of nerve-structure visible to the naked eye. All traces of roots of nerves within the theca were obliterated.[1]

[In the treatment of severe sprains, the early stage of concussion, and other injuries of the spine, Erichsen[2] advises the prone position. In this position, in consequence of the spine being the highest part of the body, determination of blood and venous congestion at the seat of injury are less liable to occur than in the supine position. The prone position is likewise the most favorable one for the application of topical treatment to the spine. There are valid reasons, however, why the prone position should not be adopted in cases in which the integrity of the cord is supposed to be destroyed, among which, it is scarcely necessary to observe, are embarrassment of respiration, arising in consequence of the weight of the body obstructing free expansion of the chest, and the difficulty that would be experienced in frequently evacuating the bladder with a catheter.]

Fractures and Dislocations of the Spine.

When violence greater than the spine is constructed to withstand is directed upon it, and it yields to the force, the injury almost invariably consists in mixed fracture and dislocation. This union of the two is readily understood when we take into view the irregular forms of the vertebræ, and the overlapping of their various processes. In the dorsal region the bones are so closely locked, and the processes, especially the spinous, so long and overhanging, that simple dislocation appears impossible; but in the cervical and lumbar regions, where motion is free, and the articular surfaces are either more horizontal than vertical, or the processes stand out apart, a considerable amount of dislocation may take place, accompanied with but little fracture. For example, a case has been related by Mr. Holmes, of a man struck on the loins by a heavy log of timber; the last dorsal vertebra had been dislocated from the first lumbar, with laceration of the intervertebral substance; but the fracture of the processes was so inconsiderable, that the fact of their having been crumbled, rather than broken, might easily have escaped notice.[3]

And, practically, the question of the proportionate amount of fracture compared with dislocation, is in most cases of little moment. It would be founding on a false analogy to suppose that, because it is important in a case of accident to the hip, shoulder, elbow, etc., to recognize distinctly the nature of the injury, whether it be fracture or dislocation, the same thing held with regard to the spine. What renders injuries of the back of gravest interest to the surgeon, is the question of the condition of the Spinal Cord; and that organ is

[1] The other preparations connected with this case are contained in the Museum of the Middlesex Hospital.

[2] Sci. and Art of Surg., 7th ed., vol. i., p. 511.]

[3] Pathol. Soc. Trans., vol. x.

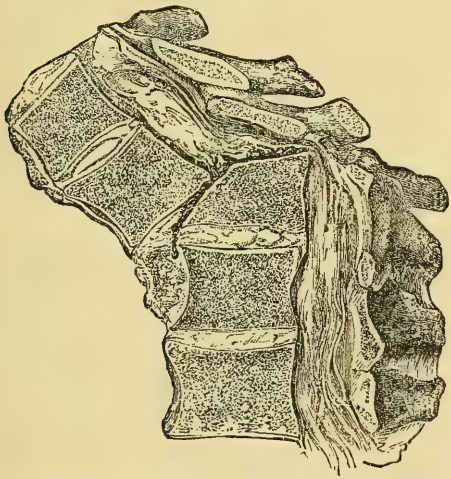
equally liable to be crushed, and have its functions destroyed, by fracture, or by dislocation. As to the treatment, if reduction of the displaced bones be required, the method of effecting it will be the same in both kinds of injuries; and as to prognosis, the prospect of recovery is not more or less encouraging in the one than in the other.

The forces which cause fracture of the vertebræ (comprehending in that term, for the convenience of expression, partial dislocation) are necessarily violent; they also fall upon the flexible column in many different directions; and they produce thereby a great diversity in the injuries. It will simplify the subject, if we distinguish fractures into those which come from *indirect*, and those which come from *direct* violence. Injuries affecting the two highest vertebræ, as they have certain special characters, will be considered afterwards by themselves.

On fractures of the spine from indirect force:

A miller's carman was standing in his wagon, receiving heavy sacks of corn let down by ropes from the high story of a granary; the fastening of one of the sacks slipped; it descended, and alighted on his neck and shoulders; the spine was fractured at the fifth dorsal vertebra.—A young gentleman was sitting on the branch of an apple-tree, when it broke, and he came to the ground on his nates, which left their impression on the soil; the spine was broken at the eighth dorsal vertebra.—A man falling headlong from a height, came to the earth upon the vertex; bruises of the scalp were visible at that part, and it was found that he had fracture of the lowest cervical vertebra.

Fig. 163.[1]



All these cases were examples of the spine being broken in a transverse direction, consequent on the column having been bent to an excessive degree; and that by forces which bore upon the column, not in the line of the fracture, but along the longitudinal axis. In examining the body of a person who has died shortly after such an accident, the following appearances will be observed: blood will be extravasated extensively in the neighborhood of the fracture; at the lumbar region, one or two of the supra- and interspinous ligaments will be ruptured, and a gap made between the corresponding spinous processes; at the dorsal, a chipping-off of the slender ends of these processes will more probably be met with; there will be partial laceration of the muscles and tendons in the vertebral grooves, at the seat of fracture. Proceeding more deeply, the ligamenta subflava connecting the arches of the two vertebræ most involved in the injury will be found torn off from the margins of the laminæ. The injury to the articulating processes will differ in the several regions; in the dorsal the ligaments will be torn, and the processes themselves be almost certainly broken; in the cervical, the ligaments will be ruptured, but the processes may either escape fracture, or have their edges merely chipped; they will probably have been dislocated, but owing to the surfaces of these processes being comparatively broad and nearly on the same horizontal level with the bodies of the vertebræ, they frequently fall into their places again after the separation; thus constituting it a case of *diastasis*, rather than of dislocation. In the lumbar region, the articulating processes will be wrenched asunder, like teeth drawn from their sockets; but when the vertebræ settle down, the processes will not return to their original situations—one or both will hitch upon some point of the subjacent vertebra, on which they can rest; the bones will thus be locked and permanently displaced, there will be a distinct bend, accompanied with a twist of the spine, and the transverse processes of one side will project visibly against the skin. Consequent on the separation of the articulating processes and the simultaneous rupture of the ligamenta subflava, the interior of the vertebral canal will be opened and the sheath of the spinal cord exposed, probably obscured by extravasated blood. Omitting, at present, to speak of the medulla spinalis itself, attention may next be drawn to the state of the front of the col-

[1] Example of fracture of the spine from indirect violence. The patient, a young man, had fracture through the eleventh dorsal vertebra, from a heavy weight falling on his shoulders, and doubling him up. He survived, with paralysis and anæsthesia of the lower extremities, for eight days. The two ends of the spinal cord, where it and the theca were torn, were one and a half inch apart. Preparation in Museum of Middlesex Hospital.

umn, viz., the bodies of the vertebræ and intervertebral substance. In treating of Sprains it was stated that when the spine is bent forwards and downwards, the force directed on it in front is one of compression, as distinguished from laceration. Accordingly, in cases of fracture caused by excessive bending, the injurious effects on the bodies of the vertebræ will be due to crushing in contradistinction to tearing. It might perhaps have been thought that when the ligaments and other structures at the back of the spine had been rent, and the superincumbent weight was thus thrown exclusively upon the bodies and fibro-cartilages, the latter would have been detached from the surfaces of the bones, rather than that the bodies should be broken. But such laceration of the intervertebral substances is rare. The chief injury inflicted consists in the breaking down of the body of the particular vertebra which is situated at the angle of flexion, and the fracture is a combination of "comminuted" and "impacted." With the fracture of the body, the longitudinal ligaments in front and behind are commonly torn. The upper fragment may glide a short way downwards and forwards upon the lower, and in that manner overhang it; but owing to the locking of the processes behind, that motion is arrested and the displacement is never considerable. In others, when a triangular portion of the body has become loose, it has been driven back, owing to the compression being greatest in front, with the force of a wedge into the vertebral canal, so as to encroach on the spinal cord.

On fractures of the spine from direct force: dislocation.—Owing to the spine being protected on its fore part, it is not liable to be injured by direct force except from behind. Again, when direct violence sufficiently great to produce fracture is applied, it causes the column to bend backwards, before breaking; or in an opposite direction to the incurvation preceding fracture by indirect violence. Hence, according to the mechanical law before referred to, the structures in front will be subject to laceration—those behind to compression: in other words, before the spine breaks, the bodies of the vertebræ, intervertebral cartilages, and longitudinal ligaments will resist the action of being torn; while the pedicles, laminæ, and processes of the posterior segment will resist the force of compression.

As the vertebræ in the dorsal region are curved anteriorly, and so firmly locked together as to be nearly inflexible, it is not to be expected that they will yield readily to a force bending them in a contrary direction. But the case will be different in the cervical and lumbar regions. In each of these the natural curve is backwards, and these are also highly flexible. We may conclude, therefore, that when either part is subjected to direct violence, and the incurvation is increased beyond the normal point, the bodies of the vertebræ will be divorced from each other, and the intervertebral cartilages stripped from the surfaces; but that the posterior arches, together with the articular, transverse, and spinous processes, will be compressed, ground, and crushed. From this it will be seen how much more likely dislocation is to enter into the composition of a direct than an indirect fracture. If one of the intervertebral substances have been torn, and the surfaces of the bodies of the corresponding vertebræ separated, there will remain only the joints of the articulating processes to hold the bones together; and when these have been broken, nothing will be left to prevent displacement of the fragments. The case related by Mr. Holmes, already adverted to, of dislocation at the dorsi-lumbar region, illustrates this view. The patient had been struck on the loins by a heavy piece of timber, and his lower extremities and bladder were immediately paralyzed: the lowest dorsal vertebræ were observed to be half an inch in advance of the level of the lumbar vertebræ: by extension, the bones were restored, with an audible click, to their proper places; after death the intervertebral substance between the last dorsal and the first lumbar vertebræ was found ruptured, and the anterior common ligament stripped off the body of the latter bone; the articular processes on both sides had been separated, and there was partial fracture of the transverse processes.

A remarkable case of fracture in the lumbar region, combined with dislocation of an extraordinary amount, caused by direct violence, has been recorded lately by Mr. Le Gros Clark; and the description of the injured parts is illustrated by a woodcut. The patient had received a blow on the back, by the fall of a heavy weight, and paralysis of the lower extremities was the consequence. The intervertebral substance between the fourth and fifth lumbar vertebræ, and other connecting ligaments of the bodies, had been completely torn; the arch of the fourth vertebra had also been broken at its pedicles, on each side; and the articular, transverse, and spinous processes, in relation with the fifth vertebra, were so crushed or comminuted, that an effectual loosening between them had taken place. The fifth vertebra had preserved its place upon the sacrum, defended from injury by the projecting posterior spinous processes of the ossa ilii on its flanks. But the body of the fourth vertebra—with its superstructure, the spine—had been forced downwards and forwards in the direction of the pelvis, to such an extent by the weight, that it was found to have taken its place in front of the body of the fifth vertebra, in the manner of front and rear rank;

the upper and under surfaces of the bodies of both vertebræ being respectively on the same horizontal level.[1]

Of injuries to the spinal cord consequent on fracture.—When the vertebral column is broken across at any point between the occiput and the second lumbar vertebra, where the medulla spinalis terminates, that important organ partakes of the injury; it is deprived of its functions, and all the body below the fracture at once loses, more or less completely, both motor power and sensation: in other words, the patient is affected with paraplegia.

From this statement it will be perceived that the higher in the spine the fracture occurs, the graver will be the consequences. But before attending to the differences in the effects referrible to the extent of the body paralyzed, let us examine the lesions produced in the spinal cord itself and its membranes, from the injuries.

Owing to the small size of the medulla, it is seldom destroyed partially; the columns which give motion and those which give sensation are almost always deprived of their functions simultaneously. When exceptions occur, and one property alone is destroyed, it is motor power that in the majority of cases is lost.

The lesion of the cord varies in different cases. 1. When the displacement of the vertebræ has been extreme, the theca has been found torn through, and the cord itself ruptured, with the ends separated to a distance of two inches from each other. 2. In many cases the medulla is intruded upon by the sharp edge of an angular fragment of vertebra; the theca and other membranes are penetrated, and the organ itself cut and torn across: in the majority of such cases, the fragment which projects into the canal is a part of the body, and is therefore situated in front. 3. In the cervical region, when the vertebræ have been both torn from each other, and extensively bent, the cord may be found not only crushed, but burst; from the violence of the squeeze, the pia mater will have given way, and the medullary substance, converted into a thin pap, will have escaped and be spread on the surface of the organ above and below the rupture. 4. The structure of the cord is not unfrequently disintegrated through its whole thickness; and yet from the pia mater being entire, the organ may retain its natural figure, or there may be a slight swelling alone visible, without discoloration; but when the finger is carried along the surface, with the view of judging of its consistence, and comes to the part corresponding to the seat of fracture, the cord will be felt soft, as if broken; and on a section being made, the medullary and cineritious matter will be found diffluent, commingled, and stained in the centre with blood. 5. The terminal portion of the cord, where it tapers to a point, opposite the two last dorsal and two first lumbar vertebræ, is surrounded by a congeries of roots of the nerves which form the cauda equina; these roots enveloping it serve to protect it to a considerable degree from injuries incident to that region of the column. The writer has seen a small superficial indent in the cord, covered by the roots at this part, produced by fracture. Lastly, below the second lumbar vertebra, the spinal canal contains only the sheath, and the cauda equina within it. It is obvious that the effects of injuries of the column in this locality will differ greatly from those in other situations, on account of the absence of the spinal cord. Both from the firm consistence of the roots composing the cauda equina, and the toughness and looseness of the sheath, the parts will yield, and adapt themselves to extensive changes in the canal, produced by displacement from fracture, without losing their functions.

In lesions of the spinal cord, the hemorrhage is generally slight; and it differs in all cases, both in its mode of occurrence and effects, from what is met with in injuries of the brain. The arteries and veins which permeate the medulla are remarkable for their minute size: hence, when a portion is cut or bruised, the bleeding soon stops, and extravasation on the surface, or ecchymosis in the substance of the organ to a considerable amount, is rare. If the latter take place, it will be greatest in the central cineritious matter. The hemorrhage in fracture of the spine proceeds chiefly from laceration of the large venous plexuses which line the interior of the vertebral canal. The blood collects on the outside of the cord and its membranes; and as the theca adheres rather firmly in front, but on the lateral and posterior parts somewhat loosely to the canal, the accumulation of blood is commonly greatest behind and at the sides.

Consequences of destruction of the spinal cord from fracture stated generally.—When a man has met with an injury of such severity as to give rise to fracture of the spine, there is a general shock to his nervous system, and he is found, at first, in a state of profound collapse. When restored, he complains of pain at the seat of the injury, especially if any attempt be made to move him. The tumefaction at the painful part, together with irregular projections and depressions in the processes of the vertebræ, divulge the nature of the accident. It is soon perceived that his whole body

[1] Lectures on the Principles of Surgical Diagnosis, delivered at the Royal College of Surgeons; by Mr. F. Le Gros Clark, Brit. Med. Journ., October 3, 1868.

below the level of the fracture is completely paralyzed. If a line, corresponding to the distribution of the nerves which come off immediately above that part, be drawn around his chest or abdomen, he will be incapable of feeling, when pricked or pinched, in any part of the skin from that line to the soles of the feet; he will be unable to move any joint of his limbs; there will not even be reflex actions of the muscles. The urinary bladder will have lost the power of expelling its contents; and as the kidneys go on secreting the ordinary quantity, it will ere long be overdistended. As the patient is not prompted by the natural call to pass his water, the bladder will at length be elevated as high as the umbilicus, feeling like a hard globular body, and giving out a dull sound on percussion. The fæces will also be retained; at first, with obstinate costiveness; afterwards, the stools will pass involuntarily; but the patient will not be aware of their escape, or of their presence when they lodge on the bed-clothes. There will be priapism, in greater or less degree.

Fracture in the dorsi-lumbar and lower lumbar region.—It will be convenient, in treating of fracture as it occurs in the several regions of the spine, to commence with those about the base; the effects being less complicated there than higher in the column.

So generally does paralysis of the lower extremities result from fracture of the spine, that the two events are apt to be looked on as inseparable. Yet, when the column is broken below the second lumbar vertebra, there may be an absence of paralysis. The patient will be unable to keep the body erect; and he will be incapacitated from walking; or he will carry himself lamely in a bent posture. But lay him on his back, and he will throw his limbs freely about, and sensation will be perfect. As soon as there has been time for union of the fragments, he will be well, except for the deformity that may remain. The reason of this difference in the effect of fracture of the spine when it occurs in the part specified, compared with other places, is that the injury is below the level of the spinal cord, which, it has been already stated, terminates at the second lumbar vertebra. From that bone downwards, the vertebral canal is occupied only by the cauda equina, protected by the membranous sheath; these are suspended loosely in their place, so that even if the displacement of the fragments, in cases of fracture combined with dislocation, be great, the long, flexible, cord-like roots composing the cauda can slip aside, elude positive injury, and retain their functions.[1] It may be expected, however, that exceptions will be met with. If the separation of the broken fragments has been extensive, the fibres of the cauda equina will be torn from their connections with the cord; and it is probable that the injury to the latter from that cause will give rise to paraplegia.[1]

If the fracture has taken place at a point higher up in the spine—as between the second upper lumbar, and second lower dorsal vertebræ—in which situation the cord is surrounded by the closely-set roots of the cauda equina, it may be expected that the effects will be moderated by the protection which the roots give to the cord. When the fracture has been caused by excessive violence, and the column has been abruptly bent, and the fragments much displaced, it is probable that the injury will reach the cord, and the paraplegia be of the usual kind. But it appears that, in numerous instances, the roots ward off the danger, and the lesion of the cord is consequently slight. In proof of this, it will be found, by examining the records of cases in which fractures have occurred in this locality, that in a large proportion of them the paraplegia which has ensued is only partial—motor power, in the greater number of examples, being lost, while sensation remains. Again, in further confirmation,

[1] Four cases of fracture in the lower lumbar region, in which there was total absence of paralysis, have come under the writer's observation. In the first, the displacement was so great, that the spinous and transverse processes projected visibly; the fragments were interlocked, so that the spine could not be straightened, and the patient's body was permanently much bent: yet motion and sensation in the lower extremities were retained from the first. See London Medical Gazette, vol. xviii., p. 936, 1836. For the other three cases, see Transactions of the Pathological Society of London, vol. iii., p. 420. Among the latter, was that of a boy who was eight years old when his case was published. Fourteen years afterwards (1865), he called, to show the condition of his spine. There was relatively greater prominence of the displaced vertebræ than at first; but the column was on the whole nearly straight, and his muscles were powerfully developed. Casts of the back, at the two different periods, are preserved in the Museum of the Middlesex Hospital.

"In one case I found the trunks composing the cauda equina lifted a third of an inch on a bridge of bone, formed by the displacement of a fractured lumbar vertebra; but they were in no degree compressed, and except a little ecchymosis in their pia mater, showed scarcely any trace of injury." Mr. Hutchinson, in London Hospital Reports, vol. iii., p. 360.

[1] In the case of fracture with dislocation of the fourth lumbar vertebra, quoted at p. 802, in which the fragments were displaced in an extraordinary manner, there was complete paraplegia at first. But in five weeks the patient recovered sensation perfectly, and motion partially. He died in the seventh week, exhausted by sloughing bed-sores.

it will be perceived that the number of cases in which patients have recovered the power over their limbs and sensation, when these have been lost from fracture at this part, is much greater than in any other.[1]

Fracture in the dorsal region, between the tenth and fourth vertebræ.—Owing to the small size of the cord at the part here denoted, it is liable to be crushed through its whole thickness, when the spine is broken anywhere in its course. Complete paraplegia may therefore be anticipated: the lower extremities will be deprived of motion and sensation; the bladder and rectum will be paralyzed, and the patient be exposed to have extensive sloughs on his back. Respiration will be imperfect, but not to such a degree as of itself to imperil life. From the diaphragm and upper third of the thorax continuing to perform their functions, inspiration will be accomplished with considerable force. But, owing to the paralysis of the abdominal muscles, the act of expiration will be feeble; yet it will be effected—first, through the elasticity of the walls of the chest, which will descend and collapse with a certain impulse, at the end of each inspiration; and, secondly, through the resilience of the abdominal viscera. If the patient should have had fracture of one or more ribs in connection with that of the spine, or, before the accident, had been subject to chronic bronchitis, the dyspnœa will be dangerously aggravated. If the patient's life be prolonged till union of the fracture has been effected, the probability of his surviving, although with paralysis remaining, is much increased. And some circumstances favor the procuring of union, in cases of fracture about midway in the dorsal region. First, owing to the rigidity of the column at this part, the displacement of the fragments is not commonly so great as elsewhere. Secondly, from the ribs acting on each side like splints, and the extensive overlapping of the processes of the vertebræ, the broken surfaces are kept in apposition and at rest. Should union be obtained, an important advantage will be gained, especially in regard to the healing of the bed-sores. The large sloughing sores, with profuse discharge, which form over the sacrum and adjoining prominent bones, with formidable rapidity, in cases of fracture of the spine, are known to be frequent causes of their fatal termination. And that which principally gives rise to these sores and prevents their healing, is the constant pressure to which they are subject, from the inability of the patient to change his position, and the irritation produced by his lying unconsciously for long periods on parts of the bed wet and soiled from the urine and fæces passed involuntarily. The chief difficulty met with in endeavoring to avert these evils proceeds from the breach of continuity in the spine, considered as the beam that ties the upper to the lower divisions of the body. It is obvious that, owing to the loosening of the connection between the superior and inferior portions of the column, at the seat of fracture, a movement of the pelvis and lower extremities will not be accompanied with a corresponding movement of the trunk above, but that the lower fragment of the spine will rotate on its axis, while the higher will remain stationary. Whatever care, therefore, be taken by intelligent nurses, in turning the patient successively on different sides, to protect the sores from pressure—however attentive they may be, in moving one division of the body, to make the other move along with it—a great deal of friction between the opposing broken surfaces will be produced, most prejudicial to union, and the source of irritation to the system. But if the patient should live sufficiently long for the ends of the fragments to be knit together, even although it be only by fibrous connections at first, and more especially by ossific matter, the obstacles referred to will be removed. It will be practicable and safe to keep him lying on each side alternately, and the sores will immediately put on a healing aspect.

Fracture in the cervico-dorsal region.—This part of the column, it has been already stated, being the point of junction between a flexible and inflexible portion of the spine, is peculiarly liable to fracture. It is understood to comprise within its lim-

[1] A series of five cases of recovery from paraplegia, caused by fracture of the spine in the dorsi-lumbar and lower lumbar regions, all occurring within a short period of each other, has been recently published in the third volume of the London Hospital Reports. The titles of the cases are subjoined:

"Fracture of the Spine in the lower lumbar region, with displacement—Paraplegia, with Paralysis of the Sphincters—Gradual improvement—Recovery in four months," p. 326.

"Fracture of the first Lumbar Vertebra with slight displacement—Incomplete Paraplegia at first—becoming more complete two or three days afterwards—Nearly complete Paraplegia for a fortnight—Gradual improvement—Perfect recovery," p. 327.

"Fracture of Spine, with displacement, in lumbar region—Paralysis of lower extremities, bladder, and bowels—Recovery in three months—Power of walking regained; but certain parts of the integuments of feet and nates still quite without sensation," p. 332.

"Fracture of Vertebræ, with displacement in upper lumbar region—Paralysis of motion and sensation in the lower extremities—Retention of urine and fæces—No priapism—Recovery in six months," p. 335.

"Fracture, with displacement, in the mid-lumbar region—Symptoms of spinal injury not recognized at first—Incomplete Paralysis of lower extremities—Recovery," p. 346.

its the vertebræ from the second lowest cervical to the second highest dorsal, inclusive. When fracture occurs here, the forms of the bones permit them to return easily to their normal relations, so that extensive permanent displacement is not commonly to be looked for—a too great loosening and mobility of the fragment is the chief characteristic. The kind of injury sustained by the cord is that of being crushed and broken down in its substance, rather than being compressed, or encroached upon in its sound condition. When the cord is so injured, all the body below the seat of fracture is paralyzed. On the front of the chest there will be sensation in the integument as low as the nipples; which is to be accounted for by branches of the superficial cervical plexus descending to that level; and if the injury to the cord has been above the origin of the first dorsal nerve, which joins the axillary plexus, some impairment in the motion and sensation of the upper extremities will be discovered. But the principal danger overhanging the patient is connected with his respiration. The whole series of intercostal muscles, with those of the abdomen, are cut off from their share in the action. As the principal trunk, however, of the phrenic nerve, which controls the diaphragm, comes off from the spinal cord above the seat of fracture—emerging at the interval between the third and fourth cervical vertebræ—that muscle continues to perform its important office of enlarging the area of the chest in inspiration; and as, at each relaxation of the diaphragm, the abdominal viscera, which had been thrust downward in its contraction, recoil by their elasticity toward the chest, the lungs are emptied of their air in expiration. But it is obvious that if the latter act were of the simple kind implied by the foregoing description, its operation would be extremely feeble; and that a patient breathing in that manner would not be able to expel the air with force, as in coughing or sneezing. It is to be remembered, therefore, that certain muscles lie on the outside of the chest, auxiliaries of the diaphragm and intercostal muscles. The strongest and most important of these is the serratus magnus, which, upon the scapulæ being raised and fixed, acts as a powerful muscle of inspiration.

The external thoracic nerve (external respiratory, Bell), which supplies the serratus muscle, is a kind of ally, in point of origin, of the phrenic; for it arises from the cervical portion of the cord, only a single vertebra below it, and descending behind the axillary plexus, is distributed on the outside, as the phrenic is in the inside, of the thorax. The effect of the action of the serratus is to elevate and expand the chest, by operating on the eight superior ribs to which it is attached. Accordingly when it relaxes, the elasticity of the chest causes the ribs to fall with an impulse, and to compress the lungs, thereby effecting an act of expiration. Thus both actions of respiration gain increased strength from the assistance furnished by the serratus muscle. The breathing can, therefore, in certain cases, be carried on for several days without considerable difficulty. But it becomes gradually more and more embarrassed. Owing to the paralysis of the abdominal muscles, the hollow viscera are deprived of the compression naturally exercised upon them; hence gases are apt to be developed within them, and the tympanitis thus produced disturbs the respiration. Again, from the difficulty of expelling the air from the lungs, the mucus accumulates more or less abundantly in the bronchial tubes, and cannot be duly expectorated: the consequence is that the blood is imperfectly oxygenated. In the majority of instances, patients do not survive beyond five or eight days; but in a few the term extends to ten or fifteen.

When fracture is situated higher up in the neck, but is still below the point at which the phrenic nerve comes out from the cord, say at the fifth, or even fourth, cervical vertebra, and the upper extremities are included in the paraplegia, death may commonly be expected within a few hours, or at most a day or two. Nevertheless, extraordinary examples are occasionally met with of patients living for a long time after the fracture.

A notable case of that kind has been recorded by Mr. Hilton. The patient, at the age of twenty-one, fell from a tree, a height of forty feet, and had fracture of the spine in the cervical region. The arms as well as the legs were paralyzed; so were the rectum and bladder. He lived for fourteen years in that paralyzed condition, and at last came to his death by being upset on a hard road, while being drawn on a low cart by a boy.[1]

The writer is indebted to Mr. Page, of Carlisle, who attended the patient, for the following notes of a still more remarkable case:

"A gentleman, twenty-six years of age, the heir to extensive landed property in the south of Scotland, while in the act of running on the edge of a terrace adjoining his father's mansion, accidentally fell upon a hard road beneath, a height of ten or twelve feet, and injured his neck. From that moment every part of the body, with the exception of the head, was completely paralyzed, the power of rotating the head being all that remained to him. In that state, without the slightest variety as to the extent of the paralysis, he continued up to the time of his death; which took place nearly fifteen months after the accident. At the post-mortem examination, it

[1] See Lectures on Rest, etc., originally delivered before the Royal College of Surgeons.

was found that the spinal column in the region of the neck had received a twist, which had caused some lateral displacement of the spines of the vertebræ; and this had given rise to the supposition that several of the bones had been implicated in the fracture. Such, however, was not the case, the fracture being limited to the fifth cervical vertebra; the body of which had been fractured horizontally, and a wedge-shaped portion broken off, which projected about a sixth of an inch into the canal. The whole bone, with the exception of that portion, was driven slightly forwards; consequently the size of the canal at this part was lessened, but not to such an extent as to compress the cord. Opposite the projecting wedge of bone, the cord was so nearly divided, that a portion only, of less size than a crow-quill, remained entire for a space of about three-eighths of an inch. Above and below this, the cord was reduced to a softened pulp; but beyond, it was firm and healthy. There could be no doubt but that the severance of the cord and the damage in the immediate neighborhood of that point were inflicted at the moment of the accident."[1]

Fracture at the summit of the spine.—If fracture of the spine, attended with crushing of the cord, should occur above the level of the fourth cervical vertebra—that is, above the origin of the phrenic nerve—it may be considered certain that instant death will ensue.[2] The vertebræ most frequently the subjects of the fracture or dislocation in this situation are the two uppermost, the atlas and axis. If a man be precipitated from a height and light upon his head, the impetus of his weight will be conveyed along the spine, and be concentrated at the junction of the column with the base of the skull. Again, the portion of the skull between the point where the head came to the ground and the joint will act with lever power to increase the effect.[1] A violent shock and strain will thus be directed on the atlas and axis. The effects produced vary somewhat. Perhaps the most common is fracture of the processus dentatus of the axis, at its root, with laceration of the ligamentous connections between the two bones, and dislocation of the atlas forwards. In other cases, the tooth-like process slips from the grasp of the transverse and restraining ligaments, and, freeing the atlas, allows it to slide forwards with the head. Again, the transverse ligament may be ruptured, so as to liberate the processus dentatus, and lead to dislocation. Finally, there may be transverse fracture of the slender arch of the atlas behind the articular processes. In all these injuries but the last, the atlas will have ceased to be restrained by its connection with the odontoid process from sliding horizontally forward on the axis; the weight of the head will, therefore, carry it in that direction, and the cord will be compressed, by a to-and-fro action, between the ring of the axis which is stationary and that of the atlas which advances. Its substance will be broken up; and the effect will be instantaneous death, as when an animal is "pithed."[2]

[Dr. Stephen Smith,[3] by a series of experiments on the cadaver made "with a view to determine the relative and absolute strength of the odontoid process, its ligaments, etc.," was led to the following conclusions:

1. "In a healthy condition of the parts, the odontoid process has greater strength than either the anterior ring of the atlas or the transverse ligament.

2. "The odontoid process is less liable to be fractured by external violence than the body of the axis at the insertion of the process.

3. "The odontoid process is not fractured by being driven against the transverse ligament, or anterior arch of the atlas.

4. "The odontoid ligaments have a combined strength greater than the odontoid process."

Dr. Smith states in another part of this

[1] Dr. Smith, of Moffat, with Dr. James Duncan and Mr. Syme, of Edinburgh, also attended the patient. Dr. Duncan, who conducted the post-mortem examination with Mr. Page, in a communication to the author, states that the fourth cervical vertebra was the one fractured.

[2] Mr. Curling has related a case in which the first, second, and third cervical vertebræ were fractured, and the patient lived for twenty-eight hours after the accident. The injury was caused by a heavy sack falling on the patient's head. On dissection, the cord was found, opposite to the third vertebra, in a state of pulpy softening, with slight extravasation into its substance. The explanation which Mr. Curling has given how the patient survived so long, appears correct. It is to the effect, that the force producing the fracture had been directed chiefly on the posterior segments of the vertebræ; that, at first, the cord had been injured only partially, but that subsequently its whole substance had been involved, and that instantaneous death took place when the destruction was complete.

Mr. Curling adds another case, in which the third cervical vertebra had been completely dislocated, without fracture, from the fourth, and the patient lived for two days and a half. That the phrenic nerves preserved their functions during that time may be accounted for from the roots of the fourth cervical nerve coming off from the cord a little higher than the level of the articulations between the third and fourth cervical vertebræ; and they may, therefore, have preserved their connection with the cord. London Hospital Reports, vol. i., p. 138. Also vol. iii., p. 358.

[1] See antea, p. 789.

[2] The subject of fracture of the upper cervical vertebræ in connection with the question of sudden death from unknown causes, is discussed by Dr. Alfred S. Taylor, in his Manual of Medical Jurisprudence, 8th Am. ed., p. 372.

[3] Amer. Jour. Med. Sc., Oct., 1871, p. 338.]

instructive paper that "it has been supposed that these fractures," *i. e.* fractures of the odontoid process, "occur from the sudden impulse of the process against the anterior ring of the atlas or the transverse ligament. I am satisfied, however, that the efficient agents in the fracture are the odontoid ligaments." Now when the head is forcibly driven forward, backward, or laterally, a lever-like action of the first kind is suddenly communicated to the odontoid process through the occipito-odontoid ligaments, the fulcrum being either the ring of the atlas or the transverse ligament, according to the direction of the force, and consequently fracture of the body of the axis takes place.

Fig. 164.

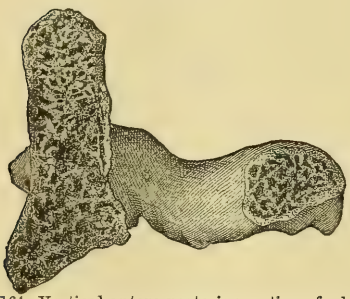


FIG. 164. Vertical antero-posterior section of odontoid process and axis.

In considering this subject it occurred to the writer that there might be some peculiarity in the structure of the body of the

Fig. 165.

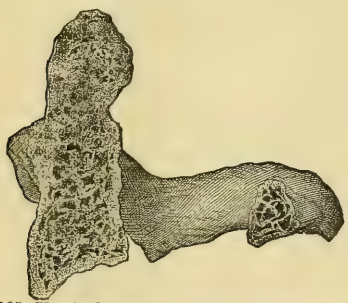


FIG. 165. Vertical antero-posterior section of odontoid process and axis.

axis and the processus dentatus, that would serve to explain why fractures of the axis should occur before either the ring of the atlas is broken, or the transverse ligament lacerated; for a superficial inspection of the axis would lead one to suppose that it was much stronger than either the atlas or the transverse ligament. Holden[1] calls attention to the fact that the structure of the odontoid process is more compact than that of the body of the axis. A vertical antero-posterior section of the odontoid process and the axis, which is seen in the accompanying cuts (FIGS. 164, 165), shows that this is undoubtedly the case.

The odontoid, likewise, has three strong vertical ridges, one on the anterior face, which extends downwards upon the body of the axis, and two lateral, which curve outwards on each side to the articular facets:[1] these ridges of bone serve as buttresses, and add materially to the strength of the base of this pivotal process. In some specimens the processus dentatus consists almost entirely of compact bone; in others there is cancellous texture, but the cancelli in the latter are much thicker and stronger than those of the body of the axis. By referring to the diagram it will be seen that the weakest part of the axis is about one centimetre below the neck of the process, where the nutrient artery enters the bone. Here the cells are large, the cancelli delicate, and the investing compact layer comparatively thin; conditions peculiarly favorable to the occurrence of fracture.]

In the Museum of the Middlesex Hospital there is preserved the axis from the body of a gentleman, who had been shot in the neck, close to the occiput, while asleep, lying on his side. The pistol-bullet had entered at the mesial line, between the arches of the atlas and axis, had passed horizontally forward, cut

Fig. 166.

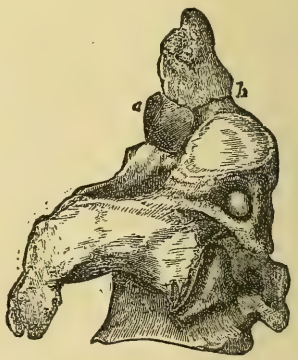


FIG. 166. *a*, pistol-bullet; *b*, fissure at base of odontoid process of axis.

through the spinal cord, and been stopped by the odontoid process, against the back of which it was found sticking, on examination after death. A fissure was also perceived running across the base of the process (FIG. 166). A female, with whom he was in bed, had been wakened before the shot was fired, and she stated that,

[1 Human Osteology, 5th ed., p. 44.]

[1 Morris's Anat. of the Joints, p. 51.]

notwithstanding the loudness of the report, the murdered man never stirred a limb, but seemed to continue his sleep undisturbed.

The same Museum contains a remarkable specimen of dislocation of the greater part of the atlas, including the articulating processes, both from the occiput and from the axis, with fracture of the odontoid process; followed by solid union of the displaced fragments. The patient, a farm laborer, had been under the care of Mr. B. Phillips. He had fallen headlong from a hay-rick; had been stunned for a short time, but then walked to the house of his medical man. He resumed his occupation in two days. A month after the accident he walked two miles to Mr. Phillips's house, and complained only of a stiffness of the neck, which prevented him from turning his head. There was a swelling in the throat, supposed to be enlargement of the tonsils; his speech was thick, and he had some difficulty in swallowing. He lived for a twelvemonth after the accident, his death being caused by general dropsy. The specimen shows the odontoid process of the axis to have been broken at its base, and the atlas fractured across at the thin parts of its arch, behind the articulating processes. The anterior segment of the atlas, consisting of the articulating and transverse processes, with the arch in front for receiving the odontoid process, had been displaced from its situation between the occiput and atlas, and transported to the forepart of the body of the axis. The broken ends of the segment, behind the articulating processes, had become firmly united to the sides of the body of the axis, against which they abutted. Thus a ring had been formed before the axis, on the same horizontal plane; and as it had some resemblance to the foramen containing the spinal cord, the specimen had the singular appearance of being a single vertebra provided with foramina for two vertebral canals.

The mode in which the displacements shown in the specimen were produced, appears to have been as follows. The fracture of the odontoid process of the axis and that of the posterior arch of the atlas probably took place first. Now these fractures would have the effect of removing the chief impediments to the segment of the atlas situated between the occiput and axis being thrown forward out of its place. Next, as the patient fell from the hay-rick head foremost, it may be inferred that, when he came to the ground, a powerful force would be directed on the cervical vertebræ in such a way as to compress the segment of the atlas on its upper and under articulating surfaces, and cause it to be shot, wedge-like, horizontally forward, and to be thrown over the edge of the axis, to lie between that bone and the pharynx. When the atlas had thus vacated its place, the condyloid processes of the occiput would settle down on the axis; and they would rest on it with comparatively greater security, owing to the odontoid process having been broken off. In course of time, new joints would be established between the occiput and axis.

It is much to be wondered at that an injury of such great severity as must have been inflicted to produce the effects exhibited in the specimen, especially considering its situation in reference to the spinal cord, should not have caused the instantaneous death of the patient. The only thing that can be noted in the way of explanation appears to be, that, from the theca near the seat of injury, namely, at the foramen magnum, being closely adherent to the vertebral canal, and from its being likewise thicker and firmer opposite to the atlas than lower down, that strength and stiffness of the membrane may have had some share in protecting the cord from being crushed, when the displacement took place.[1]

Of bed-sores.—It has just been seen that when the spine is fractured high in the column, the chief danger to life is that caused by interruption to the breathing. But in whatever part it be broken, and however low, if paraplegia has been produced, the patient will be subject to the exhausting effects of sloughs and bed-sores.

The common situations for these sores are—1. The skin over the most prominent part of the convexity of the sacrum; 2. That over the tuberosities of the ossa ischii; 3. The skin over the greater trochanters of the thigh-bones.

The time varies at which the sloughs begin to form after the accident. Equal care being supposed to be taken in all to avert them, the differences may depend on the age, constitution, and bulk of the patients. They generally manifest themselves about the fourth day; but they have been observed as early as the second. The first sign of a slough beginning is that the skin presents a white, sodden appearance; it then becomes brown and mottled, and the cuticle separates. In a short time, a patch in the centre turns black; the skin is then disintegrated, and ere long becomes pulpy and shreddy. The sloughing extends from the circumference indefinitely. If it stop anywhere, a line of demarcation will be observed. In some cases the destructive process is carried so deeply as to involve the muscles. After the slough has become detached, it is not uncommon to find the part of the sacrum over which it was formed in a necrosed condition. The vertebral canal has been opened in such circumstances, causing inflammation to spread to the membranes of the cord.

A remarkable feature in the character of these sloughs is the rapidity with which they form and extend; and that even in persons not debilitated by previous illness, but shortly before in robust health. That observation has induced some to believe that the chief cause of the production of sloughs, in cases of paraplegia from fracture of the spine, was a supposed defect of nervous influence, due to the destruction of the spinal cord. But, before accepting that as the only explanation, the peculiar

[1] For Mr. B. Phillips's account of the case, see Med.-Chir. Trans., vol. xx., p. 78. That gentleman presented the specimen to Sir Charles Bell.

circumstances of a patient suffering from the effects of a fracture of the spine ought to be considered. When a man has had his back broken, nothing is ever seen in the living body equal to the permanent fixedness of his hips and legs in the exact position in which they had been originally placed when he was first put upon his bed. There are three distinct causes for that absolute immobility. The most obvious one is his want of command over the muscles of the paralyzed parts. The second is, that, from being deprived of sensation, the patient is unconscious of pain or irksomeness from always retaining the same position; he, therefore, does not desire change, or ask his attendants to shift his position. Thirdly, the fracture of the spine itself is a cause of his inability to move; he may possess sufficient strength in his arms for lifting or turning himself; but as the beam that connects the upper with the lower part of his frame has been broken, his efforts will be abortive; and if his nurse attempt to help him, the pain and additional injury to the part will make her desist. Accordingly, the patient continues lying—quite indifferent to, or ignorant of, the bad consequences—in one settled position all day, and all night, perhaps for several days consecutively. Hence, the whole weight of his hips will press with concentrated force on the integument which covers the most projecting points of his pelvis. The skin overlying the superficial, convex, and irregular surface of the sacrum receives the principal pressure. That compression interrupts the circulation: the blood which ought to go to the part is prevented; that which ought to be there is squeezed out; the vessels are tenantless. An additional evil remains: it is almost impossible, with the greatest care, to prevent a small quantity of urine from trickling into the bedclothes; besides that, in spite of every attention, liquid fæces lodge about the anus, and are mixed with the urine; the skin of the nates becomes macerated in that noisome mess, the acrid fluid acting upon his sodden tissues like a caustic. It is not surprising, therefore, that, by the combination of an uninterrupted, inelastic, dead pressure of the skin against the sacrum, with the irritating influence of the wet bedclothes, a portion of it should soon be converted into a slough. The subject is illustrated by observing the difference in the effects when the spine has become united. As soon as the consolidation of the column has taken place, the sloughs separate, and the sores fill up with granulations, and cicatrize, although there be no amendment whatever in regard to motor power or sensation. Now that improvement is to be ascribed to the opportunity afforded of turning the patient's body frequently, and performing the various offices of nursing more effectively than before, owing to the union of the fracture. The same is witnessed in persons affected with paraplegia from tumors within the vertebral canal, or from caries of the spine when anchylosis has taken place; in these cases, by moderate attention to nursing, sloughs or bedsores may be easily averted, or healed up, if already formed.[1]

Of affection of the urinary organs.—The debilitating effects of formidable bed-sores may be readily estimated. But simultaneously with these the patient has to encounter other serious dangers connected with the urinary organs. Owing to the bladder being deprived of sensation, and the muscular coat being unable to expel its contents, disease extends to the whole series of parts, including the kidneys.

1. The bladder becomes inflamed from overdistension. The patient being no longer prompted by calls to pass his water, and the detrusor urinæ having lost its power of expulsion, there is constant danger of the urine accumulating, and filling the bladder beyond its normal capacity. That risk is met by the surgeon drawing off the water at regular intervals. But, owing to the quantity of urine secreted varying at different times, and other causes, that mode of relief is an imperfect substitute for the natural one; and the walls become occasionally overdistended. Now the effect of overdistension is an excessive stretching and tearing of the tissues of which the coats are composed; and it is reasonable to suppose that inflammation should arise from that cause. When the viscus is similarly expanded beyond its ordinary dimensions in retention of urine from enlarged prostate, inflammation is a common consequence. 2. The frequent repetition of the introduction of the catheter, imperatively called for, is another cause; owing to the patient's insensibility he gives no token of being hurt, even when the instrument is used rudely, and the surgeon is apt to be betrayed into carelessness; but, whether the operation be performed gently or not, there is reason to believe that the repeated passage of the catheter brings on inflammation in the urethra and neck of the bladder.[2] 3. Within a few days after the accident, varying from the second to the ninth, it is commonly observed that the urine, previously acid and clear, becomes alkaline and tur-

[1] See antea, p. 799 and p. 800.

[2] The writer has read and heard of more than one case of false passages being made. The swollen condition of the penis, called priapism, has been attributed to the irritation excited by the introduction of the catheter; but it occurs immediately after the accident, and before an instrument has been used.

bid; and the change is made known by the pungent ammoniacal smell. The turbid appearance is due to the addition of mucus; that increases gradually, sometimes to a large amount; and it becomes tenacious and ropy, so as to adhere to the bottom of the utensil. After a time, white matter, ascertained to be phosphate of lime, is found in the mucus. Blood is also sometimes combined with the other contents. That disordered condition of the urine generally lasts, in fatal cases, till the death of the patient. But not unfrequently its duration is temporary, and there is an alternation of periods when the urine is acid or alkaline. Cases are also met with in which the prevalent condition throughout has been that of acidity.

In explanation of these differences, it has been stated that the urine is always acid on first entering the bladder, and that the change to alkalescence takes place during its stay in the viscus. The theory is to this effect: it is supposed that when the bladder is paralyzed, the mucous membrane is deprived, at the same time, of the peculiar property possessed by it of bearing to have in contact with it an excrementitious fluid, compound and acrid in its nature, like the urine. A mutual relation of that kind exists between all the hollow viscera and their contents; as the stomach with the gastric juice, the gall-bladder with the bile, the rectum with the fæces. If the relation be wanting—for example, if the urine be extravasated into the cellular membrane, or cavity of the peritoneum, structures not endowed with the property, sloughing or high inflammation will be the consequence. Again, if the urine be kept in a utensil, chemical actions, previously restrained, will be set up. It is conceived that, in paraplegia, the influence adverted to is no longer possessed by the mucous coat; and that the affinities which bind the various constituents of the salts of the urine are changed. Hence it is supposed that the urea separates into its original elements; the disengagement of ammonia explains the ammoniacal odor; and new combinations, leading to the formation of phosphatic salts, take place from the other elements let loose. Chemical processes such as these cannot, it is said, be carried on within the bladder without exciting irritation in its coats. Accordingly, inflammation falls on the mucous membrane, and extends to the walls generally. A superabundant secretion of mucus, of a tenacious, birdlime consistence, is the consequence; and the morbid action proceeds along the ureters, till the kidneys are included. In some cases, the inflammation is of such violence that portions of the mucous membrane are thrown off, with indescribably fetid odor, as sloughs. In other chronic cases, again, calculi of phosphate of lime form both in the bladder and in the kidneys; and these set up fatal irritation in the organs generally.

A young man who was under the writer's care in the Middlesex Hospital, had fracture of one of the dorsal vertebræ, and complete paraplegia, from falling off a tree. With difficulty he passed through the dangers of extensive sloughs on his nates; and after surviving for eight months, appeared to be recovering, with paralysis. For the greater part of that time the urine flowed continuously into a urinal, and the catheter was not used. Eventually, the urine became turbid and fetid; and the patient died with symptoms of aggravated disease in the bladder. On the post-mortem examination, five phosphatic calculi, each about the size of a pigeon's egg, but of irregular angular shape, and surrounded with mucus, were collected closely together in the lower fundus of the bladder, the internal coat of which was discolored and shreddy. Calculi of the same kind were impacted in the calices, and contained loosely in the pelves, of both kidneys. In this case, pain, which is generally the most prominent symptom of stone in the bladder, had been absent. Again, owing to the patient having been confined to bed, and the detrusor urinæ having ceased to contract, the calculi were not subjected to a rolling motion; they did not acquire, therefore, the smooth, rounded form, characteristic of urinary calculi. It is probable that the inflammation which supervened at last was occasioned by the stones having gradually become so large that they reached above the level of the orifice of the bladder, blocked it up, and so obstructed the flow of the urine.

In another patient, the writer observed a remarkable peculiarity in the shape of the bladder, obviously the consequence of continual stillicidium urinæ. The patient had complete paraplegia from fracture in the dorsal region, and his water had flowed continuously into a urinal for several months before death. In the post-mortem examination, the bladder was found to be of the usual form and capacity at the lower fundus; but the upper fundus was closely and permanently contracted, so that the cavity was completely obliterated, and, to overcome the contraction, a boring action of the finger was required. It was obvious that, from the urine escaping through the urethra about as quickly as it entered the bladder, the cavity above the level of the orifices of the ureters could not be kept dilated.

Prognosis in paraplegia from fracture.—If a man be reported to have "broken his back," it is known generally to be one of the gravest of accidents. The first thing which will guide our opinion as to the probability of the patient's surviving will be the situation of the fracture. If it be below the level of the second lumbar vertebra, where the cauda equina alone is contained, it may be expected that the patient, even when the displacement is great, will retain motor power and sensation in his lower extremities, and that he will recover. Should the fracture be through either of

the vertebræ in which the terminal portion of the cord, surrounded by the roots of the nerves, is situated, the paralysis may be partial; or, though complete, the patient may have some hope of recovery. When fracture occurs in the dorsal region, the prognosis is unfavorable in all cases; but more so the higher the fracture is situated, in correspondence with the increased number of intercostal muscles thrown out of action in breathing. In fracture of the cervical vertebræ the cord is generally crushed so thoroughly and the paralysis is so general that, instead of entertaining the question of the patient's recovery, the surgeon counts by days only how long he may live. The sole hope that he clings to is the chance that the spinal cord may have been so slightly injured as to have produced only transient paralysis. If the fracture has been at the summit of the spine, in the atlas, or processus dentatus of the axis, unless the patient should escape in the remarkable manner related in Mr. B. Phillips's case, he will be dead before the surgeon can reach him.

Fig. 167.

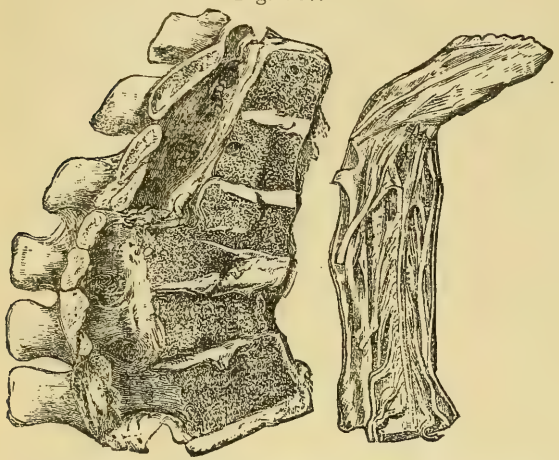


FIG. 167. The left-hand figure represents the section of a spine which had been fractured in the dorsal region, eight months before death. The fragments have become firmly united. One of the intervertebral foramina has been obliterated. The figure on the right is intended to show the disorganized and atrophied condition of the cord, in the same spine, at the seat of injury. The case is briefly referred to on the previous page. Both preparations are in the Museum of the Middlesex Hospital.

Case of recovery from fracture of dorsal vertebræ.—The following case is inserted in this place, as it illustrates some of the subjects discussed in the preceding pages.

Mr. R., thirty-two years of age, from the West of England, consulted the writer in the summer of 1860. When about nineteen years old, he fell, with a branch of a pear-tree on which he sat astride, a height of thirty feet. He was found to have fracture of the spine, between the eighth and tenth dorsal vertebræ, and complete paralysis of the lower extremities and of the bladder and rectum. At first, his life was despaired of during several weeks, on account of immense sloughs on the nates, and disease in the urinary organs, induced by the paralysis. At length the sores healed; and as promoting that, he attached great value to the use of india-rubber water-pillows, which he began to use a fortnight after the accident. These pillows he has occasionally tried to give up; but as soon as he did so, new sores formed; and he employs them to the present time, whether sitting or lying. The urine was drawn off by the catheter twice daily for three months. At first, it was extremely offensive, and loaded with ropy mucus. Subsequently, the water began to dribble away, and the introduction of the instrument was discontinued. Though there is still incontinence of urine, the bladder gets filled: he is made aware that it is distended by what he describes as a peculiar tremor felt at the pit of the stomach: he then squeezes the abdomen in the region of the bladder, with both hands, and so causes an increased quantity of urine to be expelled: the above proceeding he repeats about every third or sixth hour. During the first year he was much inconvenienced by constant or frequently recurring involuntary discharge of the fæces; since then he has had the same want of control over the passage of the stools; but the act has been performed at distant intervals, the ordinary period between them being seven or nine days; sometimes the interval is a fortnight: a short time before each action he experiences a sense of heaviness in the head, and has slight flushing of the face; and the stool which comes is immensely large and of nearly solid consistence. It was not till six months after the accident that his hips were sufficiently sound for him to sit up and be wheeled in an invalid-chair. The legs are now entirely devoid of sensation; and during the first eighteen months they were perfectly motionless. After that the effects of galvanism were tried, and ever since both limbs have been subject to sudden, and sometimes violent, startings: these are commonly excited by touching, or changing the posture of the legs; but they take place when he is lying quiet, without any apparent cause; within the last six years the strength and frequency of the convulsive actions have abated, and they have never caused pain; but, as they are both inconvenient and disturb his sleep, he is accustomed to fasten his feet by straps to the sides of the bed, by which they are counteracted. Since recovering from the dangers immediately following the accident, his health has been almost uninterruptedly good. His lower limbs, from the hips downwards, are atrophied, and the joints of the ankle, instep, and toes, stiff and distorted. But in the upper part of his body he is stout and powerfully built, the muscles of the shoulders and arms

being developed to a degree of magnitude seldom seen even in the most athletic. He drives himself in his open carriage. He was not fatigued by his long railway journey. During his stay in town he paid visits to the Crystal Palace and other show-places. He is provided with a mechanical bed, combining all the ingenious contrivances of its most improved construction.

Treatment of fracture of the spine.— Should the surgeon happen to be at hand when the accident has just occurred, his first object ought to be to guard against motion of the spine, while transporting the patient to his home. Before allowing officious persons to lift him from the ground, provision ought to be made for his being borne on a door, shutter, or the like; otherwise there will be an aggravation of the crushing and tearing of the cord. If from the seat of pain it appear that the fracture is near the neck, a sack or pillow-case ought to be filled with sand; by heaping which about the head, it can be kept steady.

When the clothes have been *cut* off (to avoid motion), and it has been found that the fracture, or fracture and dislocation, is accompanied with considerable irregularity and projection of the processes, it is necessary to bring the parts into a more favorable position for future union. But the employment of much force is to be deprecated; a gentle stretching of the body, steadily continued, may be had recourse to; but, except in rare cases, a slight change of the posture of the patient is all that is needed; when laid flat on his back, the parts tend of themselves to come into correct apposition.

[Permanent extension, by means of the ordinary weight apparatus, has been suggested in cases of fracture of the spine with deformity, when manual extension and counter-extension have failed to correct the want of proper relations between the fragments. This suggestion has been lately put to a practical test by Mr. John Wood,[1] of King's College Hospital, London, in a case of fracture of the lower lumbar vertebræ attended by complete paraplegia. The patient was placed on a water-bed, the foot of which was raised on two blocks of wood eight inches thick; as much weight as the patient could comfortably bear was applied to the legs by means of the apparatus usually known as Gurdon Buck's. According to Mr. Wood the object to be accomplished by this plan "was, as in the cases of diseased spine, to take off from the fractured surfaces, by continued, persistent, and gentle extension, the pressure of the powerful longitudinal muscles of the spine, and to insure as far as possible the apposition and rectilinear direction of the fragments of the broken spine itself."]

[1 Brit. Med. Jour., June 5, 1880, p. 838.]

In selecting an appropriate bed some foresight is wanted. The one which is to be preferred above all others, is a properly-constructed water-bed. If an invalid-couch, on the principle of Earle's, be procured, it will afford numerous facilities for nursing; by slightly bending its various joints, the trunk and limbs of the patient can be placed in a favorable position for steadying the spine at the seat of fracture: the direction of the pressure on the hips can be gradually changed from time to time; while conveniences for removing the evacuations without the necessity of lifting the patient from the bed are added. Should a bed of that kind be too expensive, the next to be preferred is a narrow one, rather low, with boards in place of sacking, and two or more elastic, yet firm, horse-hair mattresses. Mackintosh cloth, and over it a draw-sheet, should be placed under the patient's hips. Water-pillows and common feather, or horse-hair pillows, lined with oiled-silk, should be bountifully provided.

Experience shows that the application of leeches, or cupping, is not called for; that patients with paraplegia do not bear loss of blood; and that, instead of subjecting them to frequent motion in applying local remedies, it is best to preserve the spine in perfect repose.

No delay ought ever to be allowed in drawing off the urine, by the introduction of a full-sized catheter into the bladder. The patient may not have passed water for several preceding hours; he has no call to do so; and delay may be attended with injurious overdistension of the coats of the bladder. It ought to be remembered that as the patient will give no token of pain, however much the instrument may injure him, the operator ought to pass it with all gentleness. Twice in the twenty-four hours is commonly considered sufficiently often for the introduction of the catheter. But if the kidneys secrete abundantly, or if the urine become turbid and ammoniacal, a more frequent introduction may be expedient. In the latter case, the bladder ought to be washed out daily with tepid water, acidulated with nitric acid. Mineral acids may also be given internally. As incontinence of urine frequently goes along with retention, and the patient's linen is in danger of becoming wet, he ought to be furnished with a urinal; but due attention requires to be paid to that utensil, lest, owing to the insensibility of the parts, it be allowed to run over, or be upset. When the period arrives (if the patient should live) at which the neck of the bladder offers no resistance to the escape of the urine, and the latter continually runs off as water from an over-filled cask, watchfulness on the part of the attendants is more

essentially required, to prevent the bedding from becoming soiled. The constant use of the catheter will be no longer called for; but it may be proper to inject the bladder occasionally, to remove sediment that may have collected.

In the management of the bowels, it may be assumed that they will be costive in general. When the sphincter ani relaxes, and abandons its opposition to the escape of the stools, the contents cease to be discharged at regular times, as during health: they pass out, without warning, at any unlooked-for moment; accordingly, however unremitting the nurse may be in her attention to cleanliness, her efforts will be defeated. But at a subsequent period, the stools are delayed in the great intestine; they become compact; they are discharged at long intervals; and the inconvenience resulting from their passing involuntarily is greatly abated.

[Probably the best means that we can use to protect a paralyzed patient from the unpleasant consequences that are liable to arise from the involuntary escape of fæces and urine are the draw-sheet and pledgets of oakum. The draw-sheet, sprinkled with powdered oxide of zinc, should be placed beneath the hips, and care should be taken that it is kept smooth and dry. The pledget of oakum containing carbolated powder should be pushed up beneath the anus, and when the oakum becomes soiled it can be easily removed and a fresh supply substituted without moving the patient.]

Treatment of sloughs and bed-sores.—It has been stated above that the parts of the hips most liable to the formation of sloughs are those exposed to the greatest pressure, and to continual irritation from lying on bed-clothes saturated with urine and liquid fæces; that it is the skin over the sacrum, and over the tuberosities of the ischia, which gives way first. In order, therefore, to prevent the formation of sloughs, or to promote their cure, the chief objects are, first, to remove pressure; secondly, to insure cleanliness. The main obstacle to gaining these two ends, at the commencement of the treatment, is the injury committed on the fractured portion of the spine, by moving the patient's body; every time that is done, a jar is communicated to the broken surfaces; a grinding of one upon the other takes place; pain and inflammation are excited; and the process of union is interrupted. Yet, without frequently turning and lifting the patient, it is impracticable to ward off pressure, or keep the hips clean and dry. It being required, therefore, that the position of the hips should be often changed, the attendants ought to be instructed how to accomplish it with the least danger. Small pillows ought to be gently insinuated, at different times, under the hips. When compelled to turn the patient round on one side, care should be taken that the shoulders and upper part of the body are rotated, at the same time, in a corresponding degree.

As a means of protecting the skin from the chafing of the wet bed-clothes, much good might be expected from painting the surface repeatedly with collodion; but as the application would require to be renewed about three times daily, and that would necessitate the patient's body being turned on each occasion, it can only be used partially at first; subsequently, if the fracture unite, it will be found of great service. Advantage may be gained by the ring-pillow being placed under the hips, so that the central hole may come opposite the sacrum, and the weight fall on the fleshy parts on each side. Or a plaster spread on thick material (as two layers of wash-leather, including between them a layer of felt, or amadou), with a hole cut out in the centre, may be stuck on the part which it is desired to defend. Lastly, the india-rubber water-pillow, of a size adapted to the hips, and containing a little air as well as water, may be used with advantage. For keeping the bed-clothes dry, frequent changing of the draw-sheet is the chief resource; but an additional measure may be resorted to; if the patient's thighs be kept apart, and the knees slightly elevated on a pillow, a large porous sponge, or some tow, previously wetted and wrung, wrapped loosely round with gutta-percha, may be inserted deeply in the perineum: the excretions will thereby be caught, and be readily removed often. If, notwithstanding every care, a portion of the skin lose its vitality, and the cuticle begin to peel off, the amount of destruction may be limited by dressing with the linimentum terebinthinæ. When the part is more decidedly mortified, with foul discharge, cotton-wool saturated with balsam of Peru is a good application; and over that should be laid either a firm, thick linseed poultice, or a compress of cotton-wool, moistened with yeast. For cleansing foul or sloughing sores, nothing surpasses the carbolic acid lotion. Cotton-wool has the property of clinging to the skin when wet, and so prevents the under-dressing from being shifted. As the slough loosens, it ought to be clipped away with scissors. Should the surface happily become clean, and healthy granulations spring up, water-dressing, with a continuance of the measures for protecting the hips, will best favor the cicatrization.

[Among the various mechanical appliances suggested for affording support in cases of fracture of the spine, probably the plaster-of-Paris jacket promises the most satisfactory results. Dr. Hodgen, of St.

Louis, and Prof. John Ashhurst, of Philadelphia, have resorted to this plan, and they have found that by means of the jacket applied as Prof. Sayre recommends in the treatment of Curvatures of the Spine, the condition of the unfortunate patient is greatly benefited; for, instead of being doomed to lie helplessly in bed, he is enabled by the rigid support of the jacket to sit up, and, if his upper extremities are not paralyzed, he will be able to wheel himself about in a wheel-chair.[1]]

On trephining the spine.—When it is proposed, in a case of fracture of the spine with paraplegia, to trephine at the seat of injury, the object is to elevate or remove any fragment of bone that may project into the vertebral canal and compress the cord. It is supposed that, by taking off the compression, the cord will recover its lost functions, and the cure of the patient be promoted.

The operation has obviously been suggested by the analogous one performed on the head. When a man has fracture of the skull, and a portion of bone is driven in upon the brain, the surgeon applies the trephine, raises, or picks away the depressed piece; and, if the case be favorable, the patient will become conscious, recover power over his paralyzed side, and eventually get well. But the analogy between the two cases, in various points, does not hold good.

1. The relation of the skull to the dura mater and brain is widely different from that of the vertebral canal to the theca and cord. In the former, the structures are in close apposition: in the latter, the canal is separated to a considerable distance from the theca, and the theca from the cord. The effect of compression by a projecting portion of bone must, therefore, differ greatly in the two cases.

2. Owing to the small size of the cord, compared to the brain, an injury inflicted on it, such as would damage the brain only to a slight degree, might destroy its structure throughout its whole thickness, and deprive it of all its functions.

3. In the skull, fracture with depression is the result of direct force, as from a blow. In fracture of the spine, the force is generally indirect, as from a heavy body descending from a height on the head and shoulders. Now the peculiarity of the latter is that, after the breach has been made, the force does not cease to act; the weight continues to bear upon the fragments at the seat of the fracture, and so increases the displacement. The degree to which that displacement has taken place cannot be judged of by the appearance of the spine subsequently; for, owing to the elasticity of its structure, it rebounds, after having been violently bent, nearly to its original straightness. The spinal cord, however, must at the moment of breakage have undergone a severe crushing of its whole substance, at the seat of fracture. Accordingly, in performing the operation of trephining, in the two cases, there will be this great difference—namely, in operating upon the head, the surgeon will expect, after removing the depressed fragment of the skull, to find the brain throughout sound; but in operating on the spine, he will find the part of the cord situated between the fragments broken down into a soft pulp; incapable of resuming its functions, after the cause of compression has been removed.

4. In fracture of the skull requiring the trephine, the surgeon has to cut through the scalp only, in order to reach the depressed fragment. In fracture of the spine, he will be obliged to make an incision, in the line of the spinous processes, above an inch deep, and not less than six inches long, through skin and muscles—to clear the trough of the spine of its tendons and muscular fibres—and to break up the posterior arches of the vertebræ at the seat of fracture, by means of trephine, saws, bone-scissors, levers, and forceps. When he has forcibly detached the spinous processes and laminæ, and exposed the cord and sheath within the vertebral canal, he will probably learn that the fragment of bone chiefly concerned in compressing the cord is a portion of the body of one of the vertebræ, situated at a part in front quite inaccessible.

This formidable operation will have the effect, not merely of converting a simple into a compound fracture, but the bottom of the deep, ragged wound will be in communication with the interior of the vertebral canal. Hence, if the case follow a common course of compound fractures, and suppuration supervene, the pus that is formed will have free access to the space between the walls of the canal and the sheath of the cord; it may, therefore, penetrate to some distance, each way, from the seat of fracture: and it is not improbable

[1] [Dr. O. J. Caskery, of the Baltimore City Hospital, reports the case of a colored boy, aet. 19, who sustained a fracture of the ninth and tenth dorsal vertebræ, together with a simple fracture of the left leg and a comminuted fracture of the right femur. At the seat of injury of the spine there were crepitus and depression and great hyperæsthesia of the skin. Well-padded pasteboard splints were applied over the spine and from the crest of each ilium to below the knee. The splints were covered with rollers of German gauze over which was smeared plaster-of-Paris cream. In a little over five months, recovery had so far advanced that the patient could walk by pushing a chair in front of him. New York Medical Jour., vol. xxxi., p. 265, 1880.]

that, if the operation had been successful in causing the functions of the cord to be restored by the removal of the compressing fragment of bone, these functions would soon be lost again by the inflammation set up in the cord and its membranes from the presence of the pus around.

Again, let it be considered what the effect will be of dividing, in the course of the operation, the muscles and their tendons that may be in the way, and of removing portions of the posterior segments of the vertebræ at the seat of fracture. These are the principal structures by which the broken ends of the upper and lower fragments of the spine are held together. Consequently, when they are cut and taken away, the mobility of the fractured part will be greatly increased. When any attempts, therefore, are made, with the view of defending the hips from bed-sores, to vary the position of the patient by turning him round in bed, the fragments will roll freely on each other, there will be a grating of their surfaces; the attempts will be unsuccessful; and the cord will inevitably be injured.

From what has been stated in previous pages, it may have been seen that, except in those cases of fracture high in the spine in which respiration has been interrupted, the paralysis is not the direct cause of the fatal termination in cases of fracture generally. The chief dangers to life arise from extensive and exhausting sloughs and bed-sores, morbid conditions of the bladder and urinary organs generally, and, in a certain degree, from derangements of the bowels. These are indirect effects of the paralysis. But if they be overcome, the mere loss of motion and sensation in the limbs, and inability to control the actions of the bladder and rectum, will not destroy life, or be inconsistent with the patient enjoying good health.[1] The practical deduction from this observation is, that the principal aim, in the treatment, ought to be to avert those bad consequences; and endeavor to preserve life, without incurring formidable risks in expectation of getting rid of the paraplegia.

Moreover, numerous examples have been adduced to show that, especially when the seat of the fracture is at or near the dorsi-lumbar region, complete recovery is a frequent event, the patients having become strong on their limbs, and able to resume their occupations. Accordingly, in that situation in particular, the operation of trephining ought to be avoided.[2]

[1] The case related at p. 812 is a favorable illustration of what is stated in the text.

[2] On the question of the propriety of trephining the spine, in cases of fracture, with paraplegia, see the Report of a discussion on the subject, at a meeting of the Medical and Chirurgical Society, in the Medical Times and Gazette, for December 9, 1865.

See observations on the same subject, by Mr. Jonathan Hutchinson, in a Clinical Lecture on Dislocations and Fractures of the Spine, in the London Hospital Reports, vol. iii., p. 357.

See also the same question discussed, by Mr. Le Gros Clark, in his Lectures delivered at the College of Surgeons, reported in the British Medical Journal, July 17, 1869.

INJURIES OF THE PELVIS

By J. Birkett, Esq.

Revised by John H. Packard, M.D.

This essay comprises a description of the contusions of the soft parts covering the pelvis; the fractures and dislocations of the bones composing it; the injuries of the viscera contained within that cavity or connected with it, and the methods to be adopted in their treatment.

The relative situation of the pelvis to the rest of the body, the manner in which it is enveloped by muscles, the great strength of the bones themselves, the peculiar nature of their articulations and bonds of union, and the almost circular figure which results from this construction, are circumstances

which concur, individually and collectively, to resist the effects of external violence. However, whilst the bones constitute a means of protection for the contents of the cavity, they sometimes become the secondary agents in the infliction of considerable mischief, for fatal injuries are sometimes produced by their fragments perforating the pelvic viscera.

The arrangement of the subject is as follows:

I. Contusions involving the soft parts in contact with the outside of the pelvis.

II. Fractures and dislocations of the bones forming the pelvis.

III. Injuries of those organs in relation with the pelvis which are connected with the functions,

A, of Micturition;
B, of Generation, male and female;
C, of Defecation.

I. *Contusion* of the soft parts covering some portion of the pelvic bones is of frequent occurrence. Thus, a railway laborer often receives a squeeze between the buffers of two railway carriages. The result is more or less bruising of the soft tissues, and the laceration of smaller or larger blood-vessels, which, in some instances, gives rise to a large extravasation of blood. I have seen nearly the whole of the integuments detached from the external surface of the glutei muscles and fascia, without any sign of a scratch on the skin. Blood had been effused into this pouch, and a large swelling was the result. Around the swelling, ecchymosis appeared a few days after the infliction of the injury. After repose and the local application of stimulating lotions, the blood became absorbed. Large swellings, the result of the effusion of blood, occasionally arise after kicks from a man or beast, the soft parts being well placed, between the iron boot-toe or shoe and the dorsum of the ilium, to receive the full influence of such force. In these injuries, the blood is extravasated beneath the gluteal fascia, and forms a circumscribed swelling, over which the fluctuation of its fluid contents is distinctly perceptible. Ecchymosis does not appear around the swelling, even after the lapse of several days from the receipt of the injury. Under these circumstances the collection of blood might be mistaken for an abscess, if the history of the case be not carefully ascertained. The nature of the swelling may be diagnosticated, however, by learning that it appeared soon after the receipt of a blow; that no pain, before the kick was received, preceded its formation; and that its development had not been attended with any constitutional disturbance.

Contusions of an apparently trifling nature, at first sight, may yet be attended with appalling results. Thus, a delicate, strumous, badly-nourished boy receives a blow on the pelvic region, as a kick, whilst at play, the primary effects being merely local tenderness or stiffness. But in a few days intense constitutional disturbance may arise, and death ensue from disease of the membranes of the spinal cord.

II. Dislocations and Fractures of the Bones forming the Pelvis.

Injuries of the pelvic bones and joints are usually severe. They are attended with more or less risk to life, which does not ensue solely from the damage done to the bones themselves, but arises from the contents of the region being involved in the mischief.

It would be idle to write a systematic description of the dislocations and fractures of each pelvic bone separately, since fracture and dislocation occur so frequently in combination, and as the effect of the same amount of violence inflicted on the patient. Indeed, as the pelvic bones are united together by interarticular fibro-cartilage, as well as ligaments, a solution of continuity between their articulating surfaces differs widely from the displacement of the articular extremities of the long bones which compose diarthrodial joints. Hence it happens that very great violence is required to sever the union between the pelvic bones, and the same degree of force may produce a solution of continuity of the osseous texture in preference. Even in those cases in which the greatest amount of dislocation is effected, as, for example, of the os innominatum from the sacrum, the borders or edges of the articular surfaces of either one bone or the other, or even of both bones, are frequently broken off. This fact, incontestably demonstrated by preparations in every anatomical museum, renders it extremely difficult to decide during life whether the case be one of fracture simply or a combination of the two injuries. The only movable articulation, to be noticed in this essay, in which articular cartilage and a synovial capsule exist, is that between the sacrum and coccyx; and to a description of the dislocation of the latter bone a few lines will be devoted.

The massive strength of the pelvic bones of the adult skeleton and the capability of resisting violence enjoyed by the tissues which unite them together, combine to neutralize the effects of the application of ordinary force, which in bones constituted with less strength would give rise to a solution of continuity in the osseous texture. Extensive fractures are, however, occasionally repaired. There is a pelvis in the Museum of the Royal College of Sur-

geons demonstrating this fact (No. 2915 *a*). The effect of a moderate degree of direct violence, is to break off the more salient parts of the bones. Thus, a man receives a kick upon the ilium from another person, or from a horse, by which a fragment is broken off from its crest. The anterior superior spinous process of the ilium is not unfrequently separated from the crest of the bone in this manner. But in children the passage of a heavy body over the pelvic region often produces fracture. A preparation in the Museum of the Royal College of Surgeons (No. 488, Catal., vol. ii., p. 59) shows that nearly the whole extent of the os pubis may perish and become separated. The sufferer was a girl five years old, and her recovery was complete.

Fig. 168.

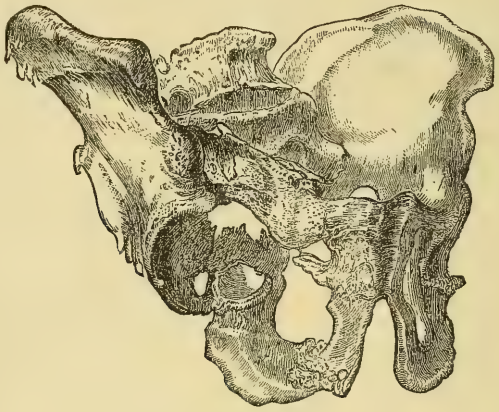
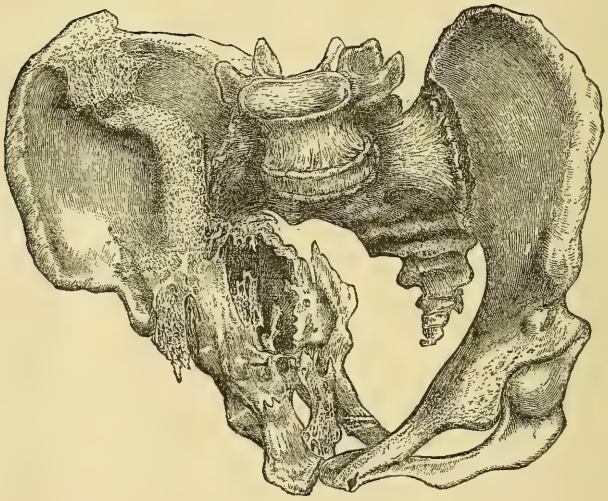


Fig. 169.



Views of a preparation (No. 2915A) in the Museum of the Royal College of Surgeons. A pelvis, the right side of which has been extensively fractured in several places and the fragments reunited; from a man aged sixty-one, who fell from a height upon some stones, August 12, 1845. After recovering from the effects of the fracture, and being able to limp about with the aid of a stick, the right leg shorter than the left, he was seized on December 3, with symptoms of typhus fever, and died December 8. See British American Journal of the Medical Sciences, September, 1849. Also Ranking's Abstract, vol. x., p. 171. (Presented by Sir George Duncan Gibb, Bart., M.D., Feb., 1868.)

The greatest amount of injury, however, is inflicted by heavy crushing weights passing over the pelvis, or by falls from great heights on to very hard substances. By such violence the bones may not only be broken and disjointed, but the important

organs within the region may also be injured by fragments of bone perforating their tissues. [Another very frequent cause of such injuries is jamming between railway cars; the brakesmen on freight trains are particularly liable to be hurt in this way.]

The treatment consists in enjoining absolute rest, and the application of a bandage in such a manner as to prevent the movement of the piece of bone which has been broken off.

The os innominatum may be broken into

Fig. 170.

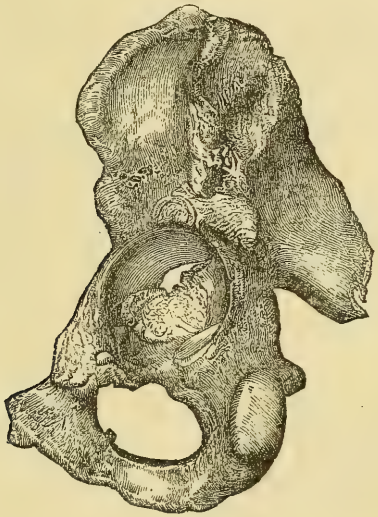


Fig. 171.

FIGS. 170, 171. Two views of the fracture of the pelvis referred to below (Museum Royal College of Surgeons, No. 2915).

The diagnosis of simple fractures of the pelvic bones is usually unattended with difficulty. Unless there be much contusion, or a large extravasation of blood over the injured bone, the crepitus, arising from the movable fragment rubbing against the fixed bone, is easily felt.

fragments by the head of the femur being violently driven against the acetabulum.

A few cases of this injury are recorded. One is related by Sir Astley Cooper in the first part of his Surgical Essays, page 51, and plate II., Fig. 6. A preparation in the Museum of the Royal College of Surgeons beautifully illus-

trates the nature of this injury, and the reparation which may take place. (Figs. 170 and 171.) The details of the case are recorded by Mr. Earle, in the nineteenth volume of the Medico-Chirurgical Transactions. It appears from the preparation, that the lines of fracture diverging from the acetabulum have followed the track of the union of the three separate portions of which the fetal bone was composed.

Mr. Moore has given the history of a case of repaired fracture of the pelvis from this cause in the Medico-Chirurgical Transactions, vol. xxxiv., p. 107. The case is of such great interest, that one of the woodcuts illustrating that paper is here introduced, by permission of the Council of the Society. (Fig. 172.)

Injuries of this kind may be mistaken for dislocations of the head of the femur, or fracture of its neck. They are usually accompanied with more or less deformity about the hip, and pain on any movement of the hip-joint. The sensation of crepitus, when the lower extremity is moved, seems to be diagnostic, however, of the nature of the injury.

Portions of the brim or border of the acetabulum are occasionally chipped off. In this injury the deformity which results simulates that of dislocation of the head of the femur; for partial displacement of the head of that bone sometimes accompanies the injury. The departure from the normal outline of the region, with the existence of the crepitus of fracture, will assist to establish the diagnosis.

In a paper by Mr. Benjamin Travers, which was read before the Medico-Chirurgical Society in 1854, he has given an account of two cases which he assumes to be illustrative of the fact of a fissure or crack passing through the acetabulum, without displacement, or any other primary sign of the nature of the injury which can be relied upon. The very acute pain produced *by pressure upon the projecting spine of the os pubis*, and the inability of the patient to maintain the erect posture immediately after the infliction of a blow or fall which produces the mischief, he considers diagnostic of the injury. There is little or no swelling, and the limb may be cautiously handled, and gently rotated, without producing much complaint on the part of the patient, being recumbent, which posture he is forced to observe for many weeks. At first the limbs are of equal length; but when the patient recovers, the injured limb is found to be permanently shortened. Mr. Travers believes there is reason to suppose, that in these accidents certain changes occur, secondarily, in the head of the femur, that it undergoes a change in shape, the articular cartilage is absorbed, and eburnation ensues. The subject certainly requires further investigation; and this short allusion to it is introduced in the hope that it may lead to more extended inquiries.[1]

Fig. 172.

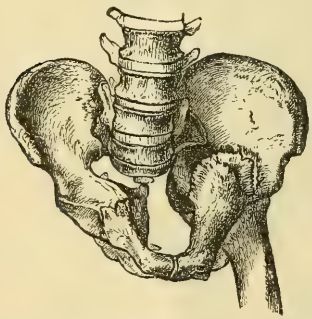


Fig. 172. Old injury of the pelvis—the head of the femur driven through the acetabulum. From Med.-Chir. Trans., vol. xxxiv.

[In the Lancet for Nov. 20, 1880, there is quoted a case in which a transverse fracture of the sacrum was sustained by a woman, æt. 36, who fell eight feet, alighting on her buttocks. Inability to sit, depression at the point of injury, crepitus, and intense pain on defecation, were the main symptoms. Complete recovery ensued.]

The coccyx can be broken, or dislocated from its articulation with the sacrum, by the application of direct force. The injury may be produced by a kick, or by a fall on any projecting hard body. It is stated that this bone is sometimes broken in the effort of parturition.

Great pain at the end of the sacrum and in the immediate region of the injured part, increased by the act of walking, or in the performance of defecation, induces the injured person to seek relief. If the bone be broken, the sensation of crepitus would be sufficient to indicate the injury. If, upon passing the finger into the rectum, and when feeling the anterior surface of the lower extremity of the sacrum, an unusual projection be felt, with mobility of the coccyx and no crepitus, it would indicate that, probably, the coccyx was dislocated either forwards or backwards. The one variety could be distinguished from the other by ascertaining which of the two bones formed the prominence on the anterior aspect of the sacrum. If the projection is formed by the base of the coccyx, this bone would be dislocated forwards. But if the end of the sacrum produces the prominence, the coccyx must have been displaced backwards.

In the treatment of fracture, absolute rest is required. The reduction of the dislocation may be effected by pressure. With the index-finger introduced into the rectum,

[1] See also Further Observations in Surgery, by B. Travers, 8vo., London, 1860.

whilst the patient is under the influence of chloroform, the bone may possibly be brought into its normal relations with the sacrum; after which perfect rest must be enjoined.

III. (A.) Injuries of the Organs of Micturition.

A. *Injuries of the urinary bladder.*—A solution of continuity of the tissues of the bladder may be caused

1. By direct violence,
   - *a.* *Without* fracture of the pelvis; produced by the passage of a wheel over the hypogastric region, by kicks, falls, and perhaps by violent contraction of the abdominal muscles.
   - *b.* *With* fracture of the pelvic bones, the fragments of which have not injured the bladder; produced by the same causes as before stated.
2. By foreign bodies penetrating its walls,
   - *a.* Through the abdominal parietes; produced by projectiles from fire-arms, bayonet or sword thrusts, and other cutting instruments, as a trocar in paracentesis abdominis, or in paracentesis of the viscus itself for relief of retention of urine.
   - *b.* From the rectum; produced by bougies, stakes of wood or iron, a trocar, etc.
   - *c.* Introduced along the urethra; produced by knives, sounds, catheters, or lithotrites.
   - *d.* From the vagina, during instrumental parturition.
   - *e.* By fragments of broken pelvic bones.
3. By accumulation of urinary secretion,
   - *a.* In the fœtus; in consequence of imperforate urethra.
   - *b.* In the adult; in consequence of an impediment to the passage of the urine along the urethra.

1. *Ruptured or burst urinary bladder.*—The tissues composing the urinary bladder may be torn or lacerated by external violence, without the abdominal walls showing any signs of the mischief. This injury may be inflicted when they are in a perfectly healthy condition; but the details of the cases prove that it only occurs when the bladder is distended with urine. Under ordinary circumstances, the anterior walls of the pelvis and the strong recti muscles protect this viscus from the effects of direct violence: but when it is distended with secretion, and the tension of the abdominal muscles is relaxed under the influence of inebriation, that part of the bladder which is in relation with the urachus, the anterior abdominal walls, and the peritoneal membrane, becomes unusually exposed and liable to be torn.

Morbid anatomy teaches that the rent may pursue a vertical, transverse, or oblique course. In the majority of instances, the aperture has been found to extend from the attachment of the urachus through the posterior wall of the organ, involving not only the proper tissues of the viscus, but its peritoneal covering as well. Under these circumstances, this great serous sac is wounded, and the urine escapes from the bladder into the cavity of the peritoneum. In some rare examples, the anterior wall of the bladder only has been torn, and the urine then becomes extravasated into the connective tissue of the pelvis.

The records of above fifty examples of this injury show that, with the exception of three, all the cases terminated fatally. Of the three cases which recovered from the injury, in one only the symptoms were those of extravasation of urine into the peritoneum;[1] in another the extravasation was in the pelvic connective tissue, and this was complicated with fracture of the pelvis;[2] and the third was of the same nature, but without that complication.[3]

In the majority of cases, the injury was produced by direct violence, such as a kick above the pubes, the passage of a cart-wheel over the hypogastric region, or the fall of an antagonist on to the same part. The injured person was generally drunk, the bladder distended, and the signs of the injury in nearly all cases were immediately manifested. In rare instances, patients have passed a few hours after the accident in comparative freedom from urgent symptoms, but they were men who were drunk at the time, and probably too anæsthetically intoxicated to be conscious of their condition. In a very few cases, the bladder was torn without any evidence of direct local violence. But these patients are said to have fallen upon their backs from a height, or down a flight of stairs.

The immediate and prominent symptoms of this injury are, intense pain in the abdomen, rapidly followed by collapse, and urgent desire to pass urine, with repeated but ineffectual attempts to void any. The patient sometimes dies at this stage. But if reaction takes place, all the well-known symptoms of peritonitis rapidly supervene, and a fatal result is sure to ensue, if this disease be not arrested. The variety of peritonitis may, or may not be of the most sthenic kind; that is, after death plastic effusions are not always to be found uniting

[1] Mr. Chaldecott's patient; Prov. Med. and Surg. Journal, 1846, p. 333.

[2] Porter's patient; the case related by F. Rhynd, Path. and Prac. Observations on Strictures, etc., 8vo., 1849, p. 48.

[3] Mr. Syme's patient; Contributions to the Path. and Prac. of Surgery, 8vo., 1848, p. 332. Possibly Dr. Thorp's case should be added to those of recovery; see page 823.

the abdominal viscera together, or forming large masses of lymph. But that kind of peritonitis is developed which is commonly associated with the most fatal results. An abundant sero-purulent effusion exists, of an unorganizable character, which bathes the abdominal viscera; and, in a few cases, it appears that fluid such as that above described has been drawn off by the catheter when introduced along the urethra and through the rent in the bladder. After the first urgent symptoms have passed off, the case becomes one of local peritonitis, and the usual train of phenomena characterizing that malady appear in succession; the only indications of the injury, in addition to those of peritonitis, being the immediate effects referable to the viscus injured. Thus the sufferer continues to evince a constant desire to micturate, and a few drops occasionally pass from the urethra, as the result of his efforts. Most commonly, however, not a drop is voided. Urgent tenesmus is another most distressing symptom, and by the repeated straining, but ineffectual attempts to defecate, a little urine may be expelled. From this continued desire to empty the bladder, and failure in voiding urine, the surgeon is induced to pass a catheter. As no impediment to the introduction of the instrument exists, and as perhaps but an ounce or two of urine flows through the tube, the catheter is pushed further into the pelvis, and, without doubt, as some of the recorded cases demonstrate, through the laceration in the posterior wall of the bladder into the peritoneal cavity. The result has been to draw off a very large quantity of fluid, in one instance, "between five and six pints;" a quantity of urine which it is difficult to believe a ruptured bladder could contain. Yet the fluid is stated to have appeared clear and normal. In some cases, the fluid drawn off by the catheter has had a little blood mixed with it, just enough to give it a slight tinge of red.

This injury must be treated like peritonitis. Suitable measures should be adopted to prevent dilatation of the bladder by an accumulation of urine, the necessity for the patient voiding it, and to guard against the possibility of repeated escape of the secretion through the laceration into the peritoneum. The case can only be regarded in this light from the first moment of the accident. For that the extravasation of urine into the peritoneum must excite inflammation of the serous membrane, can never be for a moment doubted. Post-mortem examination of the cases sufficiently attests the fact. The primary effects in the immediate neighborhood of the injured viscus are seen in the firm union of the serous surfaces, and in effusions of plastic lymph which completely shut off the pelvic region from the larger portion of the great peritoneal sac. All treatment must be subservient to that which is capable of arresting or controlling peritonitis. None can, therefore, so much conduce to the salvation of life, as that which effectually limits the primary influence of the irritating fluid to the pelvic region. The plan of treatment commonly adopted in cases of acute peritonitis must therefore be rigidly carried out in this injury. Upon opium, and its effects upon the constitution, our chief reliance must be placed. The patient should be brought under the influence of opium as quickly as possible. A full dose of tinctura opii or liquor opii sedativus, in a little camphor-julep, must be administered, and repeated at short intervals, if the abdominal pain continues. As soon as the pain subsides, the quantity of opium may be diminished, but if the pain increases, more opium is required. Food of every kind should be withheld for twenty-four or even forty-eight hours after the infliction of the injury, and then only just sufficient to sustain life allowed. A safe guide to the supply of food is indicated by the wants of the sufferer, and unless the desire for nourishment is expressed, it is better to withhold it until the necessity is pointed out by nature. Small pieces of ice placed in the mouth, to allay the distressing thirst, may be permitted to the patient *ad libitum*. The external surface of the body must be kept as warm as possible, and every measure adopted to promote cutaneous perspiration. The abstraction of blood by means of leeches applied over the region of the injury, may in some cases be desirable, but usually the attendant prostration scarcely admits of their employment. Cutaneous local counter-irritation is beneficial, and warmth and moisture applied over the abdomen favor the functions of the skin.

The conservation of the urinary bladder in a state of complete contraction and repose is one most essential step towards the healing of the wound in its walls. The surgeon should remember that the secretion of urine would be lessened, and the quantity, perhaps, become very small indeed, as generally occurs in collapse and peritonitis. Very little necessity, therefore, exists for the repeated introduction of instruments, in order to empty the bladder, during the first twenty-four, or even forty-eight hours, after the injury. A perusal of the recorded cases of this injury will not fail to impress the reader with the apparent want of caution displayed in the introduction of catheters beyond the neck of the bladder, also of the danger which must accrue when a metallic catheter is pushed far into the cavity of the organ, because so small a quantity of urine passes through it when it is really in the bladder and only

there. Will an anatomist believe that a ruptured bladder can contain "between five and six pints" of urine, or a physiologist that this quantity would be secreted in about forty hours, whilst the patient was suffering from peritonitis, the result of extravasation of urine into the peritoneal cavity? The inference, with the majority of readers, would be, that the catheter had passed through the rent in the viscus, and removed the serous effusion together with the extravasated urine from the peritoneum. The chief point, therefore, with the surgeon must be to maintain the contracted state of the bladder, because in this condition the edges of the rent remain in close approximation. And for another reason too. In a hollow viscus, constructed as the urinary bladder, the mucous membrane holds a somewhat variable position to the other tissues of which the organ is composed. The loose attachments of this membrane admit of a variation in its relations to that tissue with which it is in immediate connection, during the opposite conditions of extreme distension and contraction. So that when all the coats are torn through, in a line perfectly corresponding at the moment of extreme repletion, the non-contractile mucous coat might overlie the aperture in the other tunics, when the viscus is empty, and thus form a plug or valve to assist in preventing the further escape of urine through the laceration. And furthermore, the rent would assume very different proportions or dimensions in a dilated and a contracted state of the organ.

In order, therefore, to guard the patient against any injury which may arise from the catheter being pushed through the lacerated opening in the bladder, a large flexible instrument should be used, which has an opening at the extreme point, and not at the sides near the end, as the catheter in ordinary use has. The flow of half an ounce of urine, or even less, through such an instrument is sufficient to satisfy the operator that the bladder contains no more. The surgeon must satisfy himself upon physiological principles regarding the quantity of urine drawn off, and not calculate upon a very abundant secretion. Should the catheter be secured in the urethra? If its point could be fixed just within the orifice of the bladder, the urine as secreted would drop from the open end, and all danger of its entering the peritoneal cavity would be thus avoided. But if there be any risk of introducing it too far, or of leaving it even in the rent, it is clear that the repeated introduction of the instrument is preferable. A reply to this query must then, I think, be submitted to the judgment of the surgeon. The patient must not, on any account, be allowed to make a voluntary effort to micturate; and the use of the catheter should be persisted in for *not less* than fourteen days after the receipt of the injury.

It should be here stated that many surgeons doubt the possibility of recovery after rupture of the bladder and its peritoneal covering, that is to say, after extravasation of urine into the peritoneal cavity. Readers interested in this subject may refer to the controversy between Dr. Eben Watson[1] and Dr. Gillespie[2] on Mr. Chaldecott's case. A paper on this injury by Dr. Harrison[3] is of great interest. Recently, Dr. Thorp[4] has published a case "in which the peritoneal sac was washed out with tepid water injected through the rent in the organ," ending in recovery! It is to be much regretted that only the local symptoms of the injury are fully detailed. We vainly search in the account of the first two days after the injury for those constitutional symptoms of extravasation of urine into the peritoneum which are so constantly present after that occurrence. This omission is most unfortunate, after the introductory observations which precede the recital of the case.

The urinary bladder has been ruptured by the same local cause as produced a fracture of the pelvis. This result has happened *without* the fragments of the bones inflicting the injury to the viscus. An instance of this injury is related by Mr. Partridge, in the Pathological Transactions, vol. v., p. 194. The consequences of these injuries are usually so severe that the prognosis is most unfavorable. The treatment of the case will not differ from that before described.

2. Foreign bodies may inflict injuries on the urinary bladder, after penetration of the abdominal walls; from the neighboring canals; or from the excretory canal, the urethra; and, lastly, fragments of the pelvic bones may lacerate or penetrate its walls.

Penetrating wounds of the abdominal walls produced by projectiles from firearms, bayonet and sword thrusts, nails, spikes, the horns of animals, or surgical instruments, may extend into the urinary bladder. Bullets have lodged in this viscus, and remained in its cavity sufficiently long to become covered with deposits from the urine. Some interesting cases are related by Mr. Guthrie,[5] to which, and to

[1] Edinburgh Monthly Journal, 1848; the vol. for 1849; and the Glasgow Medical Journal, 1859.
[2] Edinburgh Monthly Journal, 1859.
[3] Dublin Journal of Medical Science, 1836, vol. ix., p. 349.
[4] Dublin Quarterly Journal, 1868, p. 306.
[5] Commentaries on the Surgery of War, 5th

the essays on GUNSHOT WOUNDS and on INJURIES OF THE ABDOMEN, we must refer the reader.

Iron or wooden stakes which have entered at or near the anus, after penetrating the walls of the rectum, may perforate the urinary bladder. Injuries of this kind are on record.

A very singular case is recorded by Mr. Prescott Hewett, in which the rectum and urinary bladder were transfixed by the patient falling upon the broken leg of a chair. Death resulted in this case from peritonitis, arising from extravasation of urine into the peritoneal cavity.[1] But a case has been described to me by my friend Mr. Buée, of Slough, in which recovery took place. A man forty-six years old, whilst at play with a companion, was pushed off a cartload of fagots, and fell on to a pointed stake which had been driven into the earth. This, passing through the anus, transfixed the walls of the rectum, and tore the posterior region of the bladder immediately behind the prostate gland. The index-finger was passed into the bladder through the wound. The man complained of intense pain. He was bled, and a full dose of opium administered. Mustard cataplasms and fomentations were applied over the abdomen. He was kept in bed, and in two months after the injury the urine was voided by the urethra. [A very similar case, occurring in a boy, was recently reported by Dr. W. Hunt, to the Academy of Surgery, of Philadelphia.]

Sounds, catheters, and lithotrites, if employed without due care, may be thrust through the walls of the bladder. Perforations may be made in the bladder with catheters, under the impression that the patient is suffering from retention of urine, whilst effusion into the abdomen is the real cause of the malady.

M. Velpeau states, that he has known this accident to occur at one of the large hospitals in Paris. The patient was sounded, and no urine came away; they pushed with greater force, and a very large quantity of serous fluid escaped. This was a case of ascites, and the instrument had penetrated the peritoneum. M. Velpeau adds, "I was sent for three times in 1832 to urgent cases, and I then saw how very easy it would have been to have made the mistake. One of the patients had not passed any urine for four days, and had his hypogastrium very much distended. I found the bladder empty. He died the same day, in consequence of an intestinal rupture, from external violence, which caused the effusion."[2]

In the use of instruments during parturition, direct injury may be inflicted on the bladder; or secondary mischief may arise by violent contusion of the part, causing extensive sloughing. And if care be not observed to ascertain whether the bladder is distended, the passage of the child's head in labor may cause it to burst. The treatment, however, of the consequences of such injuries, will be described in another essay (SURGICAL DISEASES OF WOMEN).

Cases are on record, and have occurred in my own experience, in which fragments of the pelvic bones, the result of fracture, have penetrated this viscus, causing a fatal issue from extravasation of urine.

3. The urinary bladder is sometimes ruptured by an accumulation of secretion. Cases of this kind are, however, very rare. The injury occurs in fœtal life and in the adult.

Mr. Wilkinson King has published the report of a case of a fœtus in which the bladder was burst by accumulated urinary secretion. It happened in consequence of the urethra being congenitally impervious.[1] Also, cases bearing on this subject are related by Dr. Robert Lee.[2] In the Museum of the Royal College of Surgeons, there is a preparation (No. 1967) of "the bladder of a woman which burst near the entrance of the ureter, in consequence of neglected retention of urine." See DISEASES OF THE URINARY ORGANS.

Dislocation of portions of the urinary bladder forming hernial tumors in the scrotum, is noticed in the essay on DISEASES OF THE URINARY ORGANS. A remarkable case is recorded in the Pathological Transactions, vol. iv., p. 187, illustrated by woodcuts.

Foreign bodies in the bladder.—The following remarks apply to foreign bodies introduced into the bladder along the urethra.

Portions of catheters and bougies, metallic or flexible; pieces of straw, of tobacco-pipe, pen-holders, hair-pins, a piece of French chalk, of slate-pencil, a bodkin-case;—these are all articles which have been removed from the bladder or urethra.

If the foreign body remains long in the bladder, it generally becomes coated with deposits from the urine.

In 1829 a sailor was in Guy's Hospital, under the care of Mr. B. B. Cooper. Three months before, a portion of a bougie which he was using broke off, and remained in the bladder. After many ineffectual attempts to remove it with the forceps had been made, Mr. Cooper performed the usual lateral operation of lithotomy. The piece of bougie, coated with phosphates, was removed. The man, however, subsequently sank from disease of the kidneys. The case is related in Guy's Hospital Reports,

edit., 1853, pp. 572, et seq.; also Med-Chir. Trans., vol. xxxiii., pp. 197, 198.

[1] Trans. of the Path. Soc. of London, vol. i., p. 152.

[2] Velpeau, Traité complet d'Anat. chir. gén. et topograph. du Corps humain.

[1] Guy's Hospital Reports, vol. ii., 1837, p. 508.

[2] Med.-Chir. Trans., vol. xix., pp. 238 et seq.

1844, p. 176, and the piece of bougie is in the hospital museum.

Catheters made of gutta-percha become by age and use rather brittle.

A man was admitted into Guy's Hospital under my care, who, after having used an instrument of this material for some time, broke off a piece of the end as he was removing it from the bladder. He soon felt inconvenience from it; and on examination it was easily felt with a sound, as well as some concretion which had been deposited on it. I introduced a lithotrite, and succeeded in breaking the tube in pieces. The fragments were voided with the urine by the ordinary act of micturition, and the patient was entirely relieved of his difficulty.

An elderly man, who had been in the habit of introducing a silver catheter and retaining it for some time, when in bed, fell asleep, and rolling over, broke the instrument. About half was withdrawn, leaving the remainder partly in the bladder and partly in the urethra. I introduced a long pair of forceps by the urethra, and fixing the catheter by pressure in the perinæum, was able to grasp the tube and extract it. Fortunately the broken end of the metal was rather rough and slightly bent at the site of fracture, which afforded a good hold for the forceps.

Mr. H. Norris sent to Sir Astley Cooper a number of calculi formed upon a piece of straw. The patient from whom they were removed had been in the habit of introducing a tube of this material to empty his bladder.[1]

In the Museum of Guy's Hospital there is the section of a large calculus, the nucleus of which consists of a portion of tobacco-pipe. Sir Astley Cooper used to relate a case in which the nucleus was a silver toothpick.[2]

A man entered Guy's Hospital, under my care, who had passed the wooden handle of a magnum-bonum steel-pen into his urethra and bladder, with the view to stir up some sediment which he believed to be therein. Many attempts were made with differently-shaped forceps to extract it. None of them held it sufficiently firmly to allow it to be pulled from under the pubic arch. Its end was distinctly felt through the walls of the urethra in front of the scrotum. It was necessary to open this canal at that point, and then it was easily removed.

Incised wounds of the urethra and corpus spongiosum urethræ heal very quickly, and experience has shown that the removal of bodies impacted in the urethra is accomplished with less injury to the canal by external incision than by subjecting the patient to the risk of lacerating the tissues by the use of forceps, and the pressure exerted by the foreign body to be removed.

The direction of all incisions should be parallel with the long axis of the urethra; the opening in the integuments should be larger than in the corpus spongiosum, and that in the last structure longer than in the submucous tissues and mucous membrane. The edges of the wound are on no account to be brought together with sutures, but it should be allowed to heal by granulation. There is no necessity for the introduction of a catheter.

An application was made to the late Mr. Avery to remove from a man's urethra, a two-pronged wire hair-pin, such as ladies employ to arrange their hair. The patient had introduced it with the bent end foremost, and when he let go of the pointed ends they sprang sideways, and became impacted in the walls of the urethra, at some distance from its orifice. Mr. Avery introduced a metallic tube into the urethra, pressed the points of the pin together, and conducted them into the tube, where they became fixed; both the tube and pin were then easily withdrawn.

But the strangest thing to introduce into this canal was a piece of French chalk, scraped to a convenient size and shape. At its middle, one end of a piece of string was tied, and to the other end of the string the half of a common shoe-horn. The man actually came into Guy's Hospital with this dangling from his penis. Mr. Thomas Callaway removed the chalk.

Women occasionally introduce foreign bodies into the bladder. The comparative shortness of the urethra enables the surgeon to remove them with greater facility than in the male sex. The operation may be accomplished after dilatation of the canal, when attempts made before have failed.[1] Mr. Steel removed from the bladder of a girl a bone bodkin-case, with a piece of thread tied around its middle.[2]

Foreign bodies occasionally pass from the urethra, the entrance of which into the canal is not always explicable.

An interesting case of this kind was one in which the substance seemed to be a fish-bone, which was voided by a patient who was under the observation of Mr. B. B. Cooper. It is recorded in Guy's Hospital Reports, 1841, p. 189. Mr. Alfred Roberts, of Sydney, sent to Guy's Hospital Museum a piece of slate-pencil which had been removed from the bladder, and which, as that gentleman states, is proved to have entered the bladder from a neighboring viscus.

The presence of a foreign body in the bladder having been detected, it must be removed. In the female this may be accomplished by dilating the meatus, and making use of forceps especially adapted to seize and retain the body. It may perhaps be broken with a lithotrite. In the male the length of the urethra precludes the hope of extracting a foreign body from the bladder by means of forceps introduced along the canal; but it may be crushed

[1] A relation of the case, and a drawing of the stones, is given in Guy's Hospital Reports, 1840, p. 241.

[2] Guy's Hospital Reports, 1837, p. 273.

[1] See Med.-Chir. Transactions, vols. viii. and xii.; two papers by Sir Astley Cooper.

[2] Guy's Hospital Reports, 1853, p. 316.

with a lithotrite, and the fragments afterwards expelled. If this cannot be done, an incision may be made in the centre of the perineum, the urethra opened, and the extraneous body removed by dilating the prostatic portion of the canal; or the usual operation of opening the bladder, as in the lateral operation for lithotomy, can be performed.

Injuries of the urethra.—1. *Simple incised wounds of the urethra* readily heal when longitudinal. Such wounds are dangerous in proportion to their depth, as regards their direction, and the tissues which may be implicated in the injury.

A man fifty-two years old was admitted into Guy's Hospital, under my care, in 1855, who had fallen upon a chisel a few days before admission. This instrument had inflicted a wound at the back part of the scrotum, and cut into the urethra. When admitted, the tissues of the scrotum, penis, perineum, and hypogastric region of the abdomen, were infiltrated with urine, and the integuments gangrenous in several points. Free incisions were made into the connective tissue of the regions involved in the disease; but, in spite of the liberal administration of stimuli and opium, he became delirious, and died within a fortnight after the receipt of the injury. The rule in all like cases is to prevent the infiltration of the tissues with urine; and therefore there can be no objection to enlarge the external wound, if there be the slightest reason to fear that this secretion may become extravasated. The man whose case is related above died from the effects of extravasation of urine, namely, gangrene; and had he sooner applied for relief, it is quite possible he might have lived.

Contused and lacerated wounds of the urethra.—Injuries incidental to the female urethra are rare. It is so short and so well protected by the surrounding parts, that contusions which would cause laceration of this canal in the male, generally produce their influence on the vagina or a part of the vulva. It is liable to injury in the treatment of difficult parturition, the effects of which are shown in the existence of fistulous communications between this canal and the vagina. The treatment of such cases is described in another part of this work (SURGICAL DISEASES OF WOMEN).

But the urethra of the male is often lacerated, at any age, especially in boyhood or youth. The injury is produced by violently striking the perineum in falling astride a firm resisting body, such as the top rail of an iron or wooden fence, the back of a chair, the sharp edge or corner of a box, or of any hard body, in fact, which just fits the "crotch" or perineal region. The urethra is unfortunately so placed as to receive the full violence of such a blow. For, between the pubic arch above and the resisting body below, it is violently driven against the former, and becomes torn transversely. It may even be completely severed. In this case the continuity of the mucous membrane is destroyed, and if the surrounding parts be much detached from their fascial connections, the two torn extremities of the urethra lie widely apart from one another. The portion of the canal most frequently torn in this manner is that which is placed in relation to the deep perineal fascia, and the rent may be anterior or posterior to this structure. The greatest risk to life attends the latter variety; for if extravasation of urine takes place into the connective tissue of the pelvis, the danger of intrapelvic suppuration and peritonitis is imminent.

The simplest form of injury to the urethra very often happens to boys, who in climbing over railings fall astride the topmost bar. A little blood flows from the urethra, as the immediate result of the injury; and, after the lapse of a few hours, the scrotum becomes ecchymosed and swollen. The urine voided by the efforts of the patient soon after the receipt of the injury is often bloodless, or but slightly tinged with blood. Its contact with the abraded surface gives pain, and, in consequence, the child is averse to repeat the effort. In course of time, however, he is impelled by an urgent desire to empty the bladder. Such attempts being fruitless, a surgeon is called, and his assistance is required to relieve the bladder of its contents. The retention of urine is caused partly by the effusion of blood into the cells of the corpus spongiosum urethræ and surrounding tissues, and partly by inflammatory effusion in the immediate neighborhood of the wounded mucous membrane. Great caution, care, and gentleness are required in the introduction of an instrument. It should be, at first, a flexible catheter without the stilette. Failing to introduce this, the stilette may be inserted; and if the obstacle be still insuperable, a metallic catheter must be employed. The introduction of the instrument is sometimes facilitated by gently pressing the point against the superior wall of the urethra. A catheter should not be secured in the bladder, for when this is done, the urine may ooze along the canal, by the sides of the instrument, and become extravasated into the tissues about the site of the laceration. Besides, the presence of the instrument stretches the urethra, and tends to keep the divided tissues apart. Warm fomentations or evaporating lotions should be applied to the contused regions. If there be continued hemorrhage, the local application of ice is indicated.

The following case is a good illustration of the symptoms, the treatment, and its happy

results, of a contused wound of the urethra. A man thirty-eight years old fell astride the back of a chair, and very soon afterwards passed blood from the urethra. Five hours after the receipt of the injury he was admitted into Guy's Hospital. The bladder was distended, blood flowed from the urethra, and he was suffering much from local pain. I introduced a *large* flexible catheter, through which the urine flowed freely without blood. This was secured to the penis, and allowed to remain in the bladder the three succeeding days. The catheter was then withdrawn, as the urine could not pass through it; but I was unable to introduce another. The instruments seemed to run behind the prostate gland. As the man could not void urine, I incised the perineum along the line of the raphé. This region contained much extravasated blood, and the urine flowed freely from the wound. Everything proceeded satisfactorily until the sixth day after the operation, when profuse hemorrhage occurred. It was arrested by applying cold and pressure. At the end of a month after the injury the perineal wound was entirely closed, and all the urine voided by the urethra. When he left the hospital there was no contraction of the urethra, for I could pass a large metallic sound without causing any pain.

The most extensive injury to the urethra and surrounding parts may exist without there being any indications in the perineal region for some time after the accident.

A young man was brought into the hospital who had fallen astride one of the large hooks which connect railway carriages. A few hours after the accident the perineum showed no signs of injury, and a little blood only passed per urethram. He desired to micturate; made an attempt to empty the bladder, but failed to pass a drop of urine. I introduced a flexible catheter without difficulty, and drew off an ordinary amount of urine tinged with blood. I withdrew the catheter, surmising that no impediment would subsequently arise to prevent the introduction of an instrument. However, greatly to my disappointment, the next time micturition was desired, the patient was unable to pass a drop of urine, and a catheter could not be introduced into the bladder. During the interval which had now elapsed since the introduction of the catheter, the integuments of the perineum and scrotum had become ecchymosed, swollen, and painful on pressure. An incision was made through the integuments along the whole extent of the raphé, and the severity of the injury was at once detected by gentle examination with the finger. The tissues, covered by the integuments, were extensively torn, the prostate gland could be felt; but as a very large quantity of extravasated blood filled the perineum, the wound of the urethra was not discoverable. Soon after the perineum had been incised the urine escaped at the wound, suppuration was established, and cicatrization proceeded favorably. The man was able to pass water from the urethra in a very good stream. After a time, however, the cicatrix of the urethra contracted, and a phosphatic calculus formed in the bladder. This was extracted by the lateral operation; the wound healed favorably, and the man passed water in a very good stream when I last saw him. In this case, it is not probable that the urethra was completely divided transversely.

The following case is one of complete transverse division of the urethra in the perineum. A boy, fourteen years old, was brought into Guy's Hospital in January, 1856. The penis, scrotum, perineum, and hypogastric region were black with effused blood. Retention of urine had existed many hours, and the distended bladder could be felt, as high as the umbilicus. This injury had been produced by a fall astride a rail. There was not even a scratch on the integuments anywhere. Of course, an attempt was made to pass a catheter, but it could not be introduced into the bladder. I therefore made an incision along the line of the raphé, and the urine soon began to trickle away; but I was unable to discover the vesical end of the urethra. All the urine passed through the perineal wound for some weeks, but, by degrees, through the whole length of the urethra. Only a few drops escaped by a fistulous opening in the perineum. After unsuccessful attempts to close this, I divided the perineum and urethra upon a grooved staff, and introduced a flexible catheter, in the hope that the urethra might be established by healing over it. In this I was disappointed; and the boy left the hospital with the urethra contracted, and the urine passing out of the perineal fistula. He next entered another metropolitan hospital, where the surgeon, by the performance of an operation similar to that above described, succeeded in closing the fistula, re-establishing the urethra and keeping it pervious, so long as instruments were daily employed to prevent contraction. The boy left the hospital, neglected to pass the bougie, and the urethra contracted. He then suffered from retention of urine; a No. 1 catheter was passed, and by increasing the size of the instrument the urethra was dilated. Urinary abscesses subsequently formed in the perineum, fistulæ were established, and to cure these the perineum was divided as before. This wound never entirely closed; he was again admitted into Guy's Hospital, suffering with stricture and perineal fistulæ, and left it only slightly relieved. In April, 1869, he again came under my care. The last few months he had passed in great distress. There was a small fistula in the perineum, through which he voided all the urine. I could not pass an instrument along the urethra beyond the perineum. The canal was quite closed. From the perineal fistula a probe readily passed into the bladder. That viscus was inflamed, and his constitutional powers were very low. I divided the perineum, in the middle line, and established a free communication with the anterior division of the urethra. In due time this operation was attended with complete success, and the man, now twenty-seven years old, left the hospital passing urine easily through the whole length of the urethra, but with a perineal fistula.

The danger to life resulting from extravasation of urine into the pelvic connective tissue, as a consequence of rupture of the urethra and laceration of the surrounding textures, is illustrated by the following case. It also demonstrates the ill effects arising from delay in cutting open the perineum, as well as from plugging the part with a sponge to arrest hemorrhage.

A healthy man, thirty-eight years old, fell astride a chest, and struck his perineum against one of its corners with great violence. He came soon after to the hospital, and my dresser passed a flexible catheter without any difficulty, and fastened it to the penis. The next day, the scrotum, perineum, and penis were infiltrated with blood, and quite black. The urine was passed freely through the catheter. The following day the catheter became filled with coagula, and blood passed along the urethra by its sides. It was removed forty-eight hours after the infliction of the injury, and as the urine did not flow away, I incised the perineum along the raphé. The coagulum was large, and the hemorrhage profuse. The urethra was severely torn, and the finger could be passed deeply as far as the prostate gland and by its sides. A catheter could not be introduced into the bladder. The hemorrhage was arrested by the local application of cold, and a piece of sponge placed in the wound. The next day evidences of local peritonitis appeared, pain in the hypogastric region, shivering, small wiry pulse, and at last hiccough. Opium was freely administered; but the constitutional disturbance increased, the wound became gangrenous, and the man expired upon the eighth day after the receipt of the injury. The decomposition of the body was far advanced when the post-mortem examination was made, and no well-marked indications of peritonitis or of pelvic suppuration were discernible. Death was, however, certainly due to the severe constitutional excitement caused by the injury and its consequences; and if sufficient local evidence of the fact was wanting, its absence must be attributed to the condition of the body at the time the necropsy was made. Doubtless the man died from constitutional disturbance, caused by the extravasation of urine into the pelvic subperitoneal connective tissue; and as regards the treatment of the case, the question is, whether it would not have been better to have incised the perineum sooner after the injury. In cases of this nature it is impossible to judge of the extent of the mischief in all of them, and as in this instance the catheter was in the bladder, and the urine flowed freely through it for thirty-six hours, I did not consider the operation of incising the perineum demanded immediately after admission. In all probability the extravasation of urine was extending, in consequence of the fluid escaping by the sides of the catheter, and as the coagulum was quite superficial, just beneath the integuments, the urine infiltrated the deeper-seated tissues, and passed behind the deep perineal fascia, which was lacerated. I should not again make use of a sponge and plug to restrain the bleeding, unless a catheter could be retained in the bladder; for I think it partly assisted in preventing the escape of the urine with the freedom so desirable in these cases. Local pressure with the finger is the best means to arrest hemorrhage from this region.

The local treatment in all cases of injury to the urethra, in which there is reason to fear that extravasation of urine may take place, is now clearly established. It consists in making an incision along the raphé of the perineum, so as to allow the fluid to escape with the utmost facility. Delay in the performance of this operation causes imminent risk to the life of the patient, and probably an aggravation of the local mischief.

I have, on one occasion only, used a suture to retain the divided ends of the urethra in contact. The treatment was attended with the most successful results. A very healthy boy, fourteen years old, was kicked on the perineum by a horse. He came into Guy's Hospital with retention of urine. The perineal region was filled with blood, and I was unable to pass a catheter. I divided the perineum in its middle line, and after clearing away the coagula saw the divided ends of the urethra. The orifice of the posterior division of the canal was hanging freely in the wound, having been detached from the corpora cavernosa. With a single suture, I brought the ends of the urethra together, passed a gum-elastic catheter into the bladder, and fixed it there. The wound healed rapidly; not the least contraction has followed the cicatrization, although it is now three years since the accident happened.

The constitutional treatment consists in supporting the powers of the patient, and in administering opium if there be much local tenderness, especially in the hypogastric region. Should symptoms of peritonitis arise, the treatment suitable to arrest that malady must be adopted.

Injuries of the urethra, inflicted from its mucous surface, frequently result from the passage of foreign bodies along this canal. In this category must be classed the lacerations of the urethra and its surrounding textures, by the forced introduction of sounds and catheters, in an effort made to reach the urinary bladder. The necessity for this operation arises in consequence of a contraction in some part of the calibre of the excretory tube. When, therefore, the urethra is wounded in front of the stricture by catheterism, the direction of the wound is from its orifice on the glans penis towards the urinary bladder. An opening more or less valvular is made, and extravasation of urine does not commonly take place. The course of the wound, or "false passage" as it is termed, varies much in length and in its relations to the surrounding parts. If the floor of the urethra be perforated a little behind the bulb of the corpus spongiosum urethræ, the wound may run behind the prostate gland, and then penetrate the neck of the bladder. If the point escapes through the roof of the urethra, it may run behind the pubes and enter the anterior wall of the bladder. If it escapes from the urethra in front of the stricture, it may pass by it on one side or the other, and entering the canal again posterior to the constriction, a twofold perforation of its walls will be established. In these cases extravasation of urine will be almost certain to ensue. Many of the cases of re-

tention of urine admitted into the hospitals require the operation of puncture of the bladder from the rectum, in consequence of the existence of false passages resulting from unskilful attempts made to pass an instrument through the contracted urethra. Even fatal hemorrhage may ensue from a wound of the urethra thus made.

A surgeon has often to treat these injuries. They are seen at two stages: the first, soon after the false passage has been made, when the patient has been suffering from retention of urine, and the bladder in a state of extreme distension filling up the pelvis. What is to be done? Opium in full doses has been administered; the patient has been placed in a warm bath, perhaps chloroform [or ether] has been inhaled; two or three, or even more, surgeons have failed in their efforts to introduce a catheter; not a drop of urine has escaped from the urethra, but only some blood. Upon inquiry, we find the patient has been the subject of stricture for many years, and that for some weeks the urine has only dribbled away, and at times but a few drops could be voided. To delay emptying the distended bladder is now no longer admissible, and the cries and entreaties of the patient to be relieved compel immediate proceedings. One more attempt is made to introduce a catheter into the bladder, and although different sizes are selected, and the utmost dexterity employed, still the point of the instrument will run into the false passage, and, with the index-finger in the rectum, it may be felt near the prostate gland. By depressing the shaft of the catheter, and with a little force, at the same time directing the instrument with the index-finger in the rectum, it may be made to enter the bladder. The urine flows freely, and the sufferer is at once relieved. But is the relief permanent? The bladder is empty truly, but a false passage is established, by which the urine subsequently escapes into the connective tissue between the organs of the pelvis; and the case becomes one of extravasation of urine. The condition of the patient is not, therefore, improved by this operation.

Another operation by which the distended bladder may be emptied, is that of making an incision in the centre [median line] of the perineum, and opening the urethra from that region behind the stricture. This has been successfully performed in several cases.

[The great advantage of this operation, which is really an external urethrotomy without a guide, is that the surgeon, from the time his knife enters the bladder, has entire control of the situation, and the passage of urine may be kept free, while means are resorted to for the permanent relief of the stricture. The distension of the urethra behind the obstruction has, in some of the cases under the editor's care, made the finding of the canal an easy matter.]

Two other operations are practicable. 1st, to introduce a trocar and canula from above the pubes into the bladder; 2d, with the same instruments to puncture the bladder from the rectum. I have no hesitation in strongly recommending the latter operation; and this recommendation is founded upon the observation of a very large number of most successful cases. By this procedure, extravasation of urine will be prevented. The details of the operation would be out of place here.

The second stage is that of extravasation of urine. The escape of this fluid does not always depend upon the catheter being pushed into the bladder, but may arise in consequence of the urethra bursting posterior to the constriction. This last condition generally depends upon a morbid state of the canal in that region, set up by the continued pressure of the retained fluid, by which the tissues are inflamed, and at last ulcerate or slough.

The treatment of cases of extravasation of urine need not be fully detailed here, especially as we have already dwelt upon this point when describing lacerations of the urethra causing the same lamentable consequences.

A curious injury of the mucous membrane and submucous connective tissue of the urethra occasionally takes place during the occurrence of a chordee. The patient feels something snap about two or three inches within the canal, a few drops of blood escape, and considerable tenderness or soreness is experienced during the act of micturition for a few days afterwards. The mucous membrane has been torn. The result is a cicatrization; and as the cicatrix contracts, a hard wiry ring remains, which occasionally establishes a stricture. This may subsequently require treatment by dilatation or incision.

When the urethra is lacerated in the prostatic portion of its course, the blood which flows from the wound passes backwards into the bladder, coagulates, and distends the organ. Great suffering results; constant desire exists to empty the viscus, and ineffectual attempts are made. The distended bladder may be easily felt in the pubic region, and although a catheter is passed, the size of the distension of the bladder is not diminished. Perhaps a few drops of blood and urine flow through the instrument, and that is all. Under these circumstances the viscus may be emptied by fixing a syringe to the end of a metallic catheter, which should be first introduced into the bladder. It is always advisable to make use of a larger instrument than that with which the injury was inflicted.

To make the junction of the catheter with the syringe impermeable to air, some warmed white- or bees-wax should be pressed around them at that point. Elevation of the piston slowly and steadily will then remove all the coagulated blood from the bladder. To aid the operation, a little water at the temperature of the urine may be injected.

Foreign Bodies in the Urethra.

The reader is referred, on this head, to the essay on Calculus.

(B.) Injuries of the Organs of Generation.

Injuries of the penis.—Contusions and wounds of this organ are uncommon. In contusions, the effused blood extends freely in the loose subcutaneous connective tissue, and produces an unusually dark-purple hue in the part. If blood be effused into the cells of the cavernous bodies, it produces a remarkable induration at the seat of injury, and, when general, permanent priapism for many days.

[A most remarkable case, in which by crushing force the penis was dislocated from its cutaneous sheath and engaged under the skin of the inguinal region, remaining there for eighteen days, may be found in the Philadelphia Medical Times for January 2, 1875, p. 216. The original report, by Moldenhauer, appeared in the Berliner Klin. Wochenschrift, 1874, No. 45.]

Incised and lacerated wounds of the integuments only differ from those of other parts in consequence of the loose attachment of these textures to the fibrous covering of the corpora cavernosa. When the wounds are large, their edges become widely separated, so much so in some cases as to lead to the belief that part of the integument is entirely removed.

There is scarcely any region of the body in which the edges of wounds require to be so carefully adjusted as in this. Sutures are indispensable to their treatment. Whether the wound be incised or lacerated, the edges must be maintained in contact with either metallic wire or silk sutures, and dry or wet lint should be gently rolled round the part to support it.

As the result of a contusion of the glans penis, I have seen that part of the organ become gangrenous.

A man, seventy-nine years old, said that he struck the glans penis in a fall. It became sore, inflamed, and subsequently gangrene attacked it. It sloughed off, the wound soon healed, and he passed water as well as ever.

Incised wounds of the prepuce require sutures. This fold of integument is sometimes injured in coition, and the result is more or less inflammation, giving rise to paraphimosis. The frænum præputii may be torn by the same act. Hemorrhage to a considerable extent occurs, but it is easily controlled by cold or pressure.

An injury, by no means very rare, is inflicted by children who tie a thread or string around the root of the penis. Becoming frightened, and unable to remove the ligature, they delay to speak of it, and the result is, at first congestion, afterwards inflammation, and at last ulceration at the site of the ligature. The removal of the offending cause suffices to place the parts in a condition to heal quickly, with the application of water-dressing.

The following singular deformity, which forms the subject of the woodcut, was seen in Guy's Hospital in 1867. The man was admitted under the care of Mr. Hilton for another complaint. The details are from notes taken by Mr. Eastes, then Surgical Registrar. W. D., aged 50, nineteen years ago, whilst grooming a stallion, was knocked down by the animal, knelt upon, and bitten on the thigh. The

Fig. 173.

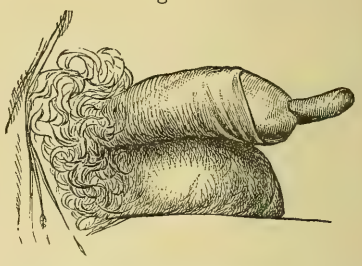


Fig. 173. Results of old laceration of the corpus spongiosum.

horse taking hold with his teeth of the trousers and penis of the man, lifted him sufficiently from the ground to enable him to clutch the manger and thereby escape. On examination of the penis he saw something projecting from the urethra, just as now represented. There was no wound on the penis, but a little blood flowed from the end of the protrusion and from the ordinary passage by its side. He was confined to the house for four weeks. The woodcut shows a cylindrical body projecting from the urethra. It was pinkish, soft and about a third of an inch in diameter and 1¼ inch long. Its end was rounded, and at the point there was a small white cicatrix. The corpus spongiosum urethræ terminated abruptly at about one inch behind the glans penis. The explanation of the appearance seems to be this. The corpus spongiosum was divided behind the glans penis, and being torn away from its attachments to the corpus cavernosum, became everted at the meatus. Micturition was performed without impediment, the urine being voided by the side of the protrusion.

Injuries of the prostate gland.—The prostate gland is so deeply seated in the pelvis, that it is not liable to injury except by penetrating wounds. Incised wounds

of the prostate usually heal very quickly. Such are those made in the operation of lithotomy. The most common injury to which this gland is liable arises from laceration either of one of its lateral lobes, or of its posterior and central part, by the forcible perforation of its tissues with sounds and catheters. This injury can scarcely be regarded as of rare occurrence, judging from the number of specimens accumulated in the museums of London. The growth connected with this gland, and denominated the "middle lobe," is frequently so situated at the orifice of the urethra as to offer an impediment, not only to the flow of the urine, but to the introduction of an instrument from the urethra. This contingency should be always remembered when any obstruction is met with at the moment the catheter reaches the orifice of the bladder. The perforation of this lobe is readily effected with a metallic instrument; it may, with care, be avoided, by the employment of a flexible catheter and stilette in most cases. When the end of the instrument impinges on the obstruction, it should be drawn from the urethra about half an inch; then, by fixing the catheter with one hand, drawing the stilette out of it for about an inch with the other, and depressing both hands, or gently pressing the catheter onwards by itself, it glides over the third lobe and enters the bladder.

The indications of perforated prostate may not be immediate. But, after the lapse of an hour or two, the patient experiences an urgent desire to empty the bladder. He repeatedly attempts to do so, but in vain. Perhaps a few drops of blood escape from the urethra. Becoming alarmed, he sends for a surgeon, who finds the pubic region occupied by a hard mass, which is very painful when pressed. The surgeon again introduces a catheter, but no urine escapes. By dint of pressure above the pubes a few drops of urine mixed with blood are expressed, then a long coagulum, again a little more blood and urine, and next a coagulum, and so on until the mass in the pelvis is somewhat reduced in size. But still there it remains, and, as an accompaniment, the urgent desire of the patient to empty his bladder. Together with these local circumstances, the constitutional disturbance hourly increases; mental excitability for a few hours is associated, at a later period, with great restlessness. Nausea, and intolerance of solid food, with a clammy white tongue, changes after a time to vomiting, continued retching, and the attendant distress. The clamminess of the mouth passes into a state of parched dryness, and the thirst is most distressing. The tongue becomes dry, brown, crisp, and rough on its surface. The pulse, at first full, rapid, and incompressible, by degrees becomes small and wiry, maintaining its rapidity, although, perhaps not regularly. Respiration is at first accelerated, and lastly hurried. The skin is covered with perspiration, which in the later stages becomes cold, and the face assumes a congested, livid aspect, not unlike that seen in cases of peritonitis.

The first thought which suggests itself to the patient as well as the surgeon, will be to relieve the distended bladder. How is this to be effected? The introduction of the catheter gives no relief, and even the passage of the instrument through the injured prostate might tend to reopen the wound. However this may be, I consider the best plan is to introduce a large metallic or flexible catheter; and then, by applying at its end a syringe, as before described, the blood may be abstracted. The bladder may be irrigated with tepid water, and the operation repeated if necessary. Cold water injected into the rectum may arrest any further bleeding.

The powers of the patient must be well supported, and sedatives or opiates administered to obtain repose.

I have never met with any injury of the vesiculæ seminales.

Injuries of the scrotum and testicles.—The scrotum is often contused, and the effect of the laceration of small vessels ramifying in its textures is shown by effusion of blood taking place in the loose connective tissue of the organ. This causes it to swell and become of a black hue. The treatment of a case of this nature demands perfect rest, with care and arrangement to prevent the part remaining pendent whilst the patient is in bed. A small pillow or sand-bag should be placed between the thighs. The most suitable application is a slightly stimulating and evaporating lotion, which may be composed of liq. ammon. acetatis, spirit. tenuior, and distilled water, in suitable proportions. [Cold water does very well.] Lint wetted with this fluid should be placed over the injured part.

Incised and lacerated wounds of the scrotum are produced by falling upon sharp substances, or astride of rails, hooks, etc. The wound is sometimes sufficiently large to permit the escape of one or even both testicles without their undergoing any injury. This extrusion of the testes partly depends upon the contraction of the fibres of the dartos, which corrugates the scrotum, and causes it to shrink to such a degree, that it might appear as if a considerable portion of the structure had been carried away as the result of the injury. Such not being the case, means must be employed to relax the contractile fibres of the dartos. Warmth and moisture will accomplish this. The region should be en-

veloped in lint wetted with hot water; and when the integuments of the scrotum are sufficiently relaxed, the edges of the wound should be drawn together over the testicles by means of sutures. Either the interrupted or uninterrupted suture may be employed, and the material of the suture be silk or metal, according to the inclination of the surgeon. Adhesive plaster is detrimental. Dry lint should be laid over the part, if the case be one of an incised wound; moist lint, if the scrotum has been contused as well as torn and lacerated. Cold lotions are then to be applied in order to maintain the contractility of the dartos, for if the integuments are allowed to become relaxed and pendulous, suppuration takes place, and the pus collects in the most depending part. Repose and posture are points of too great importance to be neglected in the treatment of these injuries.

Injuries of the testis, epididymis, and vas deferens.—The testicles may be seriously injured by pressure and contusion. The former injury frequently occurs in frays and broils by the forcible grasp of the hand of an antagonist; the latter, by suddenly coming in contact with some resisting body, as when astride a rail or a saddle on a horse's back, or by a blow from a swiftly-moving body, as a cricket-ball. The constitutional effects of these injuries are in some cases immediate. Prostration, syncope, nausea rapidly followed by vomiting, and intense pain ensue, and some hours elapse before the suffering subsides. The pain is not confined to the organ injured, but extends in the track of the spermatic cord to the inguinal, abdominal, and lumbar regions, in which last it sometimes becomes most severe. After the first effects have subsided, a hydrocele of the tunica vaginalis may be the sequel.

Absolute repose, the local abstraction of blood, the application of warmth and moisture, the support of the injured organ upon a pillow, are the local means to be adopted to prevent inflammation arising. This effect of the injury, however, frequently follows, and in the adoption of suitable constitutional and local remedies to arrest its progress, the usual precautions in regard to the diathesis and powers of the patient must be employed.

Wounds of the testicle are uncommon. A punctured wound may be inflicted by the careless use of a trocar in the performance of paracentesis scroti for hydrocele. The effect produced is more or less tenderness and swelling of the organ, and occasionally the extravasation of blood into the tunica vaginalis. If an operator has reason to conclude that the testis has been thus punctured, it would be well to enjoin rest and apply cold lotions. By neglecting all precautions he might become involved in difficulty.

Incised wounds of this organ are very rare. They cannot easily occur without the serous cavity of the tunica vaginalis being opened, and the surgeon should remember this in the adjustment of the edges of the wound. All serous surfaces being so active in pouring out adhesive lymph, the surfaces of the tunica vaginalis testis and reflexa would soon unite together when brought in contact; and thus the wound of the integuments would be all that remained to cicatrize.

Complete section of the spermatic cord with a sharp instrument should be treated with the hope that union of the divided structures may occur. The divided artery would require twisting, but the ends of the vas deferens might be adjusted by a suture placed through the surrounding connective tissue in such a manner as to keep them in close contact.

Rupture of the vas deferens.—Injuries of the excretory duct of the testis, or vas deferens, are not noticed by surgical authors. Mr. Hilton has favored me with the history of three cases, in which he believes this duct was torn completely across.

Case 1. A gentleman, between nineteen and twenty years old, was skating, and, in attempting to cut a particular figure, in which act he swung himself round with great effort, he suddenly slipped, so that his right leg was violently abducted. At the same moment he felt something give way in his right groin, accompanied with great pain. The right testis had not been the seat of direct injury, yet it began to swell almost immediately, and in a few hours blood passed from the urethra. Perfectly clear urine flowed away through a catheter introduced into the bladder, without any blood. This was an indication that the blood had entered the urethra, and that it did not come from the bladder or kidneys. The blood seemed to be arterial, but it was in small quantity. There was continued tenderness and pain near the right inguinal ring, and swelling of the right testis. Leeches were applied over the lower part of the abdomen, and he was confined to bed two or three days, suffering much local pain resembling peritonitis, with considerable pyrexia. The bleeding from the urethra did not continue after the second day. The testis remained swollen for several weeks, and then began to waste, until at last it was reduced to about one-third its normal size. At this time, now six years since the accident occurred, the patient reports that the testis is of the ordinary size of the organ in a boy of twelve years old. In its present condition it causes no inconvenience.

Case 2. A man, about twenty-eight years old, was quickly wheeling a barrow with two handles in the dark, when he was suddenly arrested in his course by the barrow meeting with an obstruction. The weight recoiled upon him, and shook him very much at the lower

part of the abdomen. He stated that he felt something "give way" in his right groin. Arterial blood flowed from the urethra almost immediately after; and when seen an hour after the injury, he was then bleeding. Mr. Hilton passed a catheter, and drew off perfectly clear and bloodless urine. This case was attended with nearly the same local symptoms as the last, although not quite so severe or so prolonged. It was treated in the same way, except that a few leeches were applied to the testis, and with advantage. A fortnight after the injury, the right testis was much enlarged, and slightly painful on pressure. The opportunity for further observation has not occurred.

Case 3. A gentleman, about sixty years old, was running up-stairs in pursuit of one of his children. Hoping more certainly to overtake the child, he made a violent effort to catch hold of her foot, as she was turning the corner of the stairs. This he failed to do, and fell with his knees upon the step, but did not strike the groin. He felt a sudden pain and something "give way" in the right groin, close to the internal abdominal ring, and presently blood trickled from the urethra. Mr. Hilton saw the patient about two hours after the injury had been inflicted. He introduced a catheter into the bladder, and the urine passed through it perfectly clear and bloodless. The patient was confined to bed for nearly fourteen days, with swollen testis and pain deeply seated behind the internal abdominal ring. Leeches were applied to the lower part of the abdomen and testicle. During four or five days a small and diminishing quantity of blood passed from the orifice of the urethra. The right testis subsequently diminished very considerably; and when an examination was made, several months after the injury, it was not more than half the size of the left.

In the details of the above cases there seem to be very good reasons to concur in the opinion, that the injury sustained by these men was laceration of the vas deferens. Mr. Hilton considers that this duct is divided within the abdomen, between the internal abdominal ring and the point where it crosses the ureter, and that the blood flows from the artery which accompanies it. The blood from this vessel traverses the tube, and so enters the prostatic portion of the urethra, anterior to the bladder, thus leaving the urine free from blood.

He adduces, in corroboration of the views above expressed, the details of a case dissected by him, in which he accidentally found one testis excessively atrophied, and the vas deferens of the same gland ruptured and closed at both ends. The ends were at least two inches apart. The lowermost was lying near the crossing of its course with the ureter; the upper end was adherent to the surrounding connective tissue, near the internal ring. The vesicula seminalis on the same side was smaller than that on the opposite.

The indications of this injury are a sudden and violent pain in the groin, arising as the result of severe exertions, or of a blow; the flow of bright-red blood from the urethra, although the urine which the bladder contains is free from blood; gradually increasing pain, which extends over the lower part of the abdomen, accompanied with more or less pyrexia. The bleeding ceases; the pain subsides; but the testis on the affected side becomes at first swollen and tender, and finally diminishes, until, after the lapse of a few weeks, it becomes atrophied.

Absolute rest in bed; the local application of leeches, warmth and moisture; and such constitutional remedies as serve to control and remove pyrexia, subserve the purposes of treatment, both general and local.

Cases of this injury are doubtless rare, and these have been here introduced to attract the notice of the profession.

Injuries of the uterus.[1]—The following arrangement will be adopted in describing the injuries of the uterus.

In the unimpregnated state:
1. Wounds. 2. Contusions.

In the impregnated condition:
1. Wounds. 2. Contusion, without and with rupture.

Rupture during parturition:
1. Idiopathic. 2. Traumatic.

Wounds of the unimpregnated uterus are very rare. Except in combination with violent and extensive injuries to the pelvis, there are, indeed, no cases on record. As Duparcque observes, "the fibrous, and as it were cartilaginous resistance of the womb whilst empty; the small size of the organ; its mobility, and its situation within a bony cavity, efficiently protect it from all violence capable of affecting the integrity of its walls."

The same remarks apply to contusions of the empty organ as to wounds.

[In the Boston Med. and Surg. Journal for 1870, p. 418, there is quoted from L'Union Médicale a case of spontaneous rupture of an unimpregnated uterus from a tumor, which would seem to have been an abscess of the wall.]

In wounds in the impregnated state, the danger depends more on the hemorrhage which may be produced, the inflammation excited, and its consequences, and the premature expulsion of the ovum which may follow, than on the fact that the uterus is wounded. Punctured wounds, or small rents by sharp instruments, may cause the dribbling away of the amniotic fluid quite as much as large injuries, thereby rendering abortion a certain result.

Many cases of goring by cattle are on record; and from the wounds so produced,

[1] In this section I have availed myself of the knowledge of Dr. Braxton Hicks, the talented accoucheur-physician at Guy's Hospital.

the whole or part of the fœtus has escaped into the peritoneal cavity, or completely through the abdominal walls.

Planchon relates a case of a pregnant uterus being punctured by a nail projecting from a cart. Blood mixed with the liquor amnii escaped from the wound. Death occurred in sixty hours.

Baudelocq mentions a case where the uterus was torn open by an ox, and recovery ensued.[1]

There is a case of recovery from puncture by a pitchfork reported in the American Journal of Medicine, April, 1847.

The pregnant uterus has been tapped with a trocar for ascites, from which mistake no ill effects followed.

The wife of a sepoy was riding on an ox, which stumbled. She fell on its horns, one of which entered her abdomen and uterus. Through the wound the hand of the fœtus protruded. The fœtus was extracted *per vias naturales*. The intestines protruded, but were replaced, and the woman perfectly recovered.[2]

The uterus has also been wounded in criminal attempts to procure abortion, the instrument used passing through its walls, producing occasionally fatal hemorrhage. A case occurred in the practice of an eminent accoucheur-physician, who examined the uterus after death, which took place from inflammation. The pointed instrument had entered the os uteri rightly, but, instead of following the axial curve, it was pushed towards the sacrum, through the posterior wall of the cervix into the recto-vaginal pouch of the peritoneum.

The treatment of wounds of the pregnant uterus depends much on the condition of the parts. If the fœtus have *not* escaped, a wound of this organ must be treated on the usual principles; perfect quietude, light dietary, and full doses of opium to check pain and uterine action. If the fœtus *have* escaped, and there is yet a probability of bringing it through the natural passages, the effort must be made with the greatest care; should, however, the greater part present at the wound, then our best plan would be to draw the remainder gently through, removing the placenta, as in the Cæsarean section, and finishing the proceeding, and adopting the same after-treatment, as in such cases. If only a small portion, as a limb, of the fœtus, project through the wound, it will be advisable to replace it, as early and with as much gentleness as possible; taking care, the moment labor sets in, to be ready to dilate the os uteri, either manually, or, still better, by the india-rubber dilating bags; and then as soon as the fœtus can be turned, either by introduction of the hand, or by combined external and internal version, we should deliver the fœtus, in order that it may not again be driven through the uterine walls by their contractions.

Contusions of the pregnant uterus, without rupture.—During the early months of pregnancy, blows and injuries may produce inflammation of this organ, the symptoms of which will be severe pain in the hypogastric region, extending to the vulva, perineum, and thighs, combined with inflammatory fever. The treatment will consist in depletion, calomel and opium, and the local application of leeches and hot fomentations. Abortion is generally the result; but abscess or chronic inflammation of the womb, or adhesions, may be the sequel. Duparcque relates a case in which an abscess formed in front of the uterus from a blow on it in the sixth month of pregnancy. It was only discovered, after delivery, by its projection across the mouth of the uterus. It was cured by puncture with a straight bistoury.

From the changes produced in the walls of the uterus by this inflammatory action, it has been observed that injuries to that organ undoubtedly predispose to rupture in subsequent pregnancies and labors.

During the latter months of pregnancy, or at the full term, contusions give rise to inflammation of the uterus and to peritonitis. They are attended with more severe suffering if the consequent contraction be more powerful, and the child larger; and labor is almost certain to follow, impeded by the swollen uterus, and the as yet rigid os.

As to the treatment: "Under these circumstances," says Dr. Rigby, "we must trust almost entirely to the lancet to aid the speedy dilatation of the os uteri; for until the circulation has received an effectual check by fainting, the dilatation of the parts cannot proceed, nor can any attempt be made to give artificial assistance. The abdomen should be well covered with a hot linseed-meal poultice, hot decoction of poppies thrown up the vagina, the bowels opened by a simple enema, and then a warm opiate injection to allay irritation." We would also recommend the inhalation of chloroform [or ether], but not carried to its fullest effect; and from what we have witnessed of its beneficial effects in obstetric operations, we may look for the greatest benefit: first by its power of checking temporarily uterine contractions; secondly, from its relaxing powers to open the os; and lastly, from its anæsthetic action.

Contusions, with rupture.—This is the most serious consequence attendant on contusions to the pregnant womb. The ovum is expelled into the abdominal cavity, or more rarely through the natural passages. Besides contusions, overexercise, leaning against hard substances, violent vomiting,

[1] See Hull's Defence of Cæsarean Section.

[2] London Medical Gazette, Oct. 1846.

and stooping and falling, have been known to cause the catastrophe.

In the early months of pregnancy the symptoms are ambiguous. They may be said generally to resemble those of rupture of any abdominal viscus. The most marked are collapse, intense pain, internal hemorrhage, or an escape of blood from the vagina. In the latter stages of pregnancy, the symptoms point more clearly to ruptured uterus, and the child may be felt among the intestines. When death does not immediately ensue, and the case is left to nature, either fatal peritonitis is set up, with all its attendant symptoms, or the fœtus becomes surrounded with a cyst, the result of plastic effusion, and is thereby shut off from the viscera. The ovum may remain tolerably quiescent in this cyst, but sooner or later it causes irritation and endeavors to reach the surface, either by the vagina, by the rectum, or through the abdominal walls.

The treatment being the same as that required when the accident occurs during labor, the reader is referred to that division.

Rupture of the uterus during parturition.—This is one of the most appalling accidents that can complicate parturition. It may be considered under two conditions: firstly, idiopathic; secondly, traumatic. The first arises from an abnormal condition of the uterine walls, its tissue being altered by former disease, or by former wounds. It may also result from prolonged efforts to expel the child where an obstruction exists in the natural passage. Sometimes the walls give way before more than a few pains have arisen, while some patients have been four days in labor before rupture took place. The average duration of labor before rupture is about twenty-one hours.

Version, and the unskilled or careless use of obstetric instruments, not unfrequently produce the second variety of this accident. Although rash and inconsiderate attempts cannot be too strongly condemned, it is important to know that rupture has occurred even to the most skilful practitioners. From the reports of some cases it would appear that violent movements of the fœtus have given rise to this accident, though it is highly probable that the escape of the child through its walls produced the violent movements of the uterus, and thus cause has been confounded with effect. If, however, the movements were the true cause, we can hardly believe that the uterine walls were in a healthy condition at the time.

Ruptures of the uterus generally may be divided into three classes. In the first the rent is confined to the vaginal cervix, and perhaps a portion of the vagina. Occasionally the vaginal portion of the cervix has come away as a ring, having been detached from the uterus at its junction with the vagina. These cases are usually without danger; they soon heal up, and probably they are much more frequent than is commonly acknowledged. Occasionally, as in a case mentioned in the Guy's Hospital Reports, 1859, the hemorrhage resulting has proved fatal. In the second class rupture is unattended with the escape of the fœtus through the rent; and in the third the fœtus escapes into the peritoneum.

The symptoms of ruptured uterus are variable, dependent on the extent of the rent, the amount of hemorrhage attending it, and whether or not the fœtus has passed through its walls. The most common symptoms are a sudden sensation of tearing, or of something having given way in the abdomen, followed by fainting, and all the symptoms of collapse, cessation of the pains, frequently recession of the presenting part, frequently hemorrhage from the vagina. These symptoms are those which more especially indicate the third class of the accident, and usually denote the escape of the fœtus into the abdominal cavity, where it can be generally felt. However, this is not always the case, for collapse may continue to a fatal end, even where the fœtus remains in utero; for bleeding into the peritoneum may cause nearly the same symptoms. Again, the uterus may be severely ruptured, and though the pains may be abated in force, they are still adequate to delivery. This termination is rare. But many cases have occurred in which it was impossible in consequence of the slightness of the symptoms to fix the time of the rupture, therefore it is not unlikely that some cases recover without the suspicion of their existence.

The treatment recommended in this formidable accident varies very much. From the researches of Dr. Trask, to whose valuable paper we must refer the reader,[1] it appears that in those cases where the fœtus had escaped into the peritoneal cavity,

Gastrotomy after this accident lost	24 per cent.
Turning, perforation, etc., . . .	68 "
Abandoned to nature, ...	78 "

In a case of such difficulty, it is well to know what line of treatment affords the greatest chance of recovery; and from the above we may safely conclude that gastrotomy affords the best, which is therefore strongly urged by Dr. Trask. However, in any given case, much depends on collateral circumstances. If the child have only in part escaped into the peritoneal cavity, then it is proper to introduce the

[1] "Cases of Ruptured Uterus, with Remarks," by Dr. Trask; American Journal of Medical Sciences, January and April, 1848, and July, 1856.

hand, seize the feet, and deliver as in version; if the head, however, be impacted in the pelvis, it is right to apply the forceps, and if that be impossible or useless, to perforate it. If the child have escaped wholly into the cavity, and only a few hours have elapsed, the hand should be passed through the rent, if it can be done with ease, the legs grasped, brought back through the rent, and delivered by the natural channels. But should much time have elapsed, or the rent be firmly contracted, so as to require some force to pass the hand through it, it will then be advisable to perform gastrotomy without delay. Again, should the escaped fœtus have, at the time of our arrival, already set up irritation, we must then wait until the plastic products of inflammation have formed a cyst around it, whereby most commonly it remains for a time comparatively quiescent. It will be a matter to determine, after waiting two or three weeks, whether we should make an opening through the abdominal walls, or delay still longer until there is a marked tendency to point forwards. In any case, should we find from the touch that the fœtus is lying just beneath the walls, there can be no hesitation in cutting down at the end of three weeks from the accident; for it must be remembered that the fœtus may take the direction of the bladder or intestines, and form openings into them, causing protracted and immense suffering. Sometimes, however, the fœtus remains in the cyst dormant for many years, but these are the exceptions.

The intestines may escape by the rent, after delivery per vaginam, and therefore in every case examination should be made, if possible, in order to reduce them when necessary; as death has taken place in some cases from strangulation of the bowel.

The laceration may take place in any direction. The relative frequency of its position is as follows: Rupture of body and fundus, 63; ditto of cervix, involving more or less of body of uterus and vagina, 64.

Injuries to the vagina.—Unconnected with parturition, these are not very common. But few are recorded. They are inflicted by falling, or sitting upon pointed instruments, which may penetrate even to the abdomen. A case is mentioned in which a triangular hay-knife entered the vagina, lacerating the perineum, and passed into the abdomen, whilst the long handle remained projecting from the vagina. The handle was cut short, and the remaining portion was extracted, after great difficulty, at the end of nine hours. Local and general bleeding was employed, and recovery took place in seven days.[1]

[1] Lancet, 1833-34, vol., p. 112, from Revue médicale.

Two cases have been related to me in which patients have died from the hemorrhage resulting from a wound inflicted on the vagina. It is a subject for regret that in neither case was the nature of the wound in the artery discovered after death, by careful dissection.

My informant was hastily summoned to a lady, whom he found lying on the floor in a pool of blood, at the point of death; in fact, she scarcely breathed after his arrival. The husband had left her in perfect health, a very short time before, to accompany a friend a little distance from the house. On his return, he found his wife on the floor, and faint. A surgeon had seen the patient, and discovering a flow of blood from the vagina, placed a compress and plug of lint therein, and gave stimulants. The hemorrhage, however, continued, and death took place about an hour after the infliction of the injury. A post-mortem examination of the wound *only* was made. On separating the labia, a lacerated wound, which extended upwards and forwards, was seen, and the internal pudic artery was found to have been divided. The accident was occasioned by the lady going into a dark bedroom to micturate, and sitting down upon a water-ewer, the handle of which was broken off, leaving a portion, sharp, jagged, and projecting about an inch, which produced the injury.

Mr. Durham, assistant-surgeon at Guy's Hospital, related to me the following case: A woman was knocked down by a man, and immediately a large pool of blood appeared on the floor. She died in a short time. The blood flowed from the vagina, in the walls of which there was a wound extending towards the internal pudic artery. At first it was thought that the woman had been stabbed with a knife, but on careful examination it was discovered that she had fallen on a spittoon. The weight of her body broke this utensil, and a sharp-pointed fragment of it probably inflicted the injury.

Injuries connected with parturition.—Rupture of the cervix uteri frequently extends into the vagina, assisting the escape of the fœtus into the peritoneal cavity, or allowing the intestines to protrude. Sometimes the vagina alone is ruptured in a circular direction, either posteriorly or anteriorly, close to the bladder. The rupture frequently extends half-way round, not very infrequently three-fourths of its circumference. The symptoms in such cases resemble those of ruptured uterus, and must be treated accordingly.

Two cases are latterly[1] on record where the uterus has been detached from the vagina, and expelled from the body during labor. In both these cases there was an inquest. It did not appear that any force had been applied to the parts; at least not sufficient to account for such an injury. Upon consideration of the forces employed in labor and of the partial laceration of the vagina, which has occurred through two-thirds of its circumference spontaneously, we may find a legitimate explanation of

[1] See Lancet and Brit. Assoc. Journ., 1st half-year, 1869.

this accident in the enormous strain on the round ligaments and vagina after the head of the fœtus has passed through the os uteri, but is arrested by the pelvis. The vagina and round ligaments form the only restraint of any importance against the recoil of the uterus; if any part give way, then undue strain falls on the rest; and if the uterus then continue in action, its force, so useful to expel the fœtus, acts against these restraining tissues till they yield. In general the ruptures of uterus and vagina cause suspension of the pains, and then the extension of the mischief ceases; but this is not always the case, and then the rupture is rapidly extended.

The unskilful use of obstetric instruments, or the extraction of the broken-up fœtal cranium, have often caused severe injuries to the vagina; sometimes the former have passed through the walls, at the junction of the cervix, tearing the uterus from the vagina.

In a case of this kind the forceps passed through the vagina behind the os uteri; the intestines protruded, and attempts were made to reduce them. They, however, continued to fall down, and the portion protruded sloughed off in about ten days. Ultimately the patient recovered with an intestino-vaginal fistula. This, after two years, was closed by a plastic operation, and then the motions passed for the first time since the operation by the rectum. There was, however, no doubt that some inches of perfect intestine had come away originally.

In attempts to procure abortion, the vagina has been injured, and occlusion or conttriction of the passage being the result, has been detected at the subsequent labor.

The vagina has also been torn, together with the hymen, in the attempts at coitus for the first time.[1] In two cases described to the writer, in recently married women, the bleeding was very alarming to both parties, consequent upon the tearing up of a considerable portion of the mucous membrane. Similar effects are also produced in rape. The legal points of these cases may be seen in works on Medical Jurisprudence.

The passage of the child's head in primiparæ will occasionally push before it the internal membrane of the perineum, so as to cause it to tear, leaving a raw surface internally, which is difficult and slow to heal. In two instances this caused contraction and severe pain afterwards. In one case coitus was impossible for nine months at least after labor. The irritation of the lochia probably retards the healing process.

[1] A specimen of this injury, which proved fatal, is preserved in the collection of obstetric preparations presented by Mr. Stone to the Museum of St. George's Hospital.

All these wounds require but little surgical interference beyond the injection of warm fomentations, great cleanliness at first, and, if they be slow to heal, some stimulating injection, as black-wash, zinc and alum lotion, a lotion of nitrate of silver, or the application of the solid nitrate.

All injuries of the vagina are exceedingly prone to be followed by contracting cicatrices, which in part or even wholly occlude the passage, rendering coitus more or less difficult, painful, and even impossible. They add very seriously to the dangers of labor, ending even in rupture of the uterus.[1] Peritonitis is apt to follow injuries of the vagina, especially if they be near the uterus. Any symptoms, therefore, of this disease must be carefully watched.

The protracted detention and pressure of the child's head within the vagina is sometimes followed by a slough, which may extend anteriorly into the bladder, causing vesico-vaginal fistula; or posteriorly into the rectum, causing recto-vaginal fistula. By the former the urine passes in part or wholly into the vagina; and by the latter the fæces, rendering the condition of the sufferer very pitiable. The treatment of the results of this injury is described in the essay on Surgical Diseases of Women.

Foreign bodies when lodged in the vagina require some skill in extracting them. The most common is the pessary, the springs of which break, and the patient, from ignorance, generally allows it to remain until the discharge becomes most offensive, simulating that from malignant disease. Severe irritation is also set up; and after a time the vagina may become so contracted around it, that it is exceedingly difficult to introduce any instrument to take hold of it. In one case the pessary had to be sawn in two parts, by a saw introduced into the vagina, before it could be removed. In another, a metal pessary was so impacted that the perineum required division to facilitate its removal. For ordinary cases a forceps made for the purpose is best.

In the London Medical Gazette, 1854, p. 264, a case is reported where a broken neck of a bottle was found in the vagina. A point of it had entered the bladder, and on this point a calculus had formed as well as around the part in the vagina.—A glass bottle was removed by the writer with polypus forceps.—An ale-glass, two inches and a half in diameter and three in height, was removed by the forceps; the case is reported in the Lancet, 1856, vol. ii., p. 451.—At Guy's Hospital a case occurred, under the care of Mr. Hilton, in which a flat bone netting-mesh, about ten inches long, was successfully removed from the pelvis of a girl, who had introduced it into that region per

[1] Trask on "Occlusion of the Os Uteri and Vagina," in American Journal of Medical Sciences, July, 1848.

vaginam. The length of the mesh necessitated its division into two parts before it was removed. The mesh is in the Museum at Guy's Hospital.[1] [See in Brit. Med. Journ. for 1874, p. 773, a case by W. H. Day, of removal of a broken glass syringe from the vagina; also in Cincinnati Clinic for 1873, p. 25, a case of a foreign body impacted in the vagina for 22 years.]

Injuries to the *vulva and external parts* arise from kicks, falls astride, sitting on sharp instruments, fire, rape, and the passage of the child's head. They must be treated upon the ordinary principles of surgery. As these parts contain much connective tissue, they very readily swell after injuries, and suppuration also extends widely and quickly throughout their tissues. As the vascularity of these organs is great, contusions give rise to large extravasations of blood, which cause remarkable discoloration of the skin for some distance around. By the application of cold at first, and subsequently a stimulating lotion, the blood soon becomes absorbed. As the result of cicatrization after burns, the entrance to the vagina may appear to be nearly closed up. But mechanical dilatation removes the deformity.

Injuries of the perineum.—In the male sex this region is liable to contusions and superficial lacerations. Boys are particularly the subjects of injuries in this part of their bodies, which occur in scrambling over rails or palings; and adults frequently bruise the part by striking it upon the pommel or some other part of the saddle in riding. The result is more or less effusion of blood into the loose connective tissue, and the appearances termed ecchymosis become visible in a day or two. Local pain or tenderness generally accompanies the swelling which results, with slight difficulty and perhaps pain in micturition. Retention of urine sometimes occurs from the mechanical pressure of the swelling upon the urethra, and therefore in children especial care should be observed to ascertain that the bladder is emptied.

Repose, and the local application of warmth and moisture, or a lotion of the liquor plumbi diacetatis dilutus, is usually all the treatment that is required.

Incised and even lacerated wounds of the integuments and deeper tissues of the perineum usually heal favorably, when treated in the manner applicable to the special case, and therefore their treatment requires no particular description here. The surgeon should, however, bear in mind the relations of the urethra to this region.

But although the primary results of a wound in the male perineal region cannot be regarded as more serious than other superficial wounds of soft parts, yet the secondary results may involve considerable risk to life. The proximity of the wound to the urethra causes the inflammation resulting from it to extend to that canal, and thus there may be excited, from an apparently trivial cause, all the dangers and difficulties accruing from retention of urine, and the usual means may be required to relieve that condition.

Let the following case illustrate this point.

A rather weak man, twenty-two years old, was admitted into Guy's Hospital in 1838, with a lacerated wound of the perineum, which penetrated merely to the muscles. The injury had been inflicted by falling off a chair and striking the perineum. At first a catheter was passed without any difficulty, but by degrees this operation became impeded by surrounding inflammation. The urethra was at last involved in the mischief, and by the introduction of a catheter it was supposed that a false passage was established. The urine escaped into the connective tissue of the perineum, and a large abscess was the result. The appetite of the patient had entirely failed soon after the accident, and great constitutional disturbance had resulted. At last hectic fever, with colliquative diarrhœa, supervened, and he sank in sixteen days after the receipt of the injury. Post-mortem examination showed that the tissues of the heart, lungs, liver, and kidneys were diseased. The cavity of a large abscess existed between the bladder and rectum, and into the last viscus there was an opening. The mucous membrane of the bladder and urethra was covered with false membranes, and there were abscesses in the walls of the bladder.

The perineum in the female sex is liable to a much more serious injury during parturition. Placed behind the vulva, the integuments and subcutaneous tissues are so much stretched during the passage of the child's head, that they are unable to offer sufficient resistance, and they become torn or lacerated. The direction of the rent is either immediately backwards, central, or a little to one side or the other. Should this accident occur, the edges of the wound may be brought together with sutures, and a fair chance of cicatrization exists. But if neglected, the surfaces heal over, and a permanent fissure will be the result. Even when the torn surfaces are covered with granulations, their suitable adjustment with the quill-suture may induce cicatrization.[1]

This subject will be found more fully treated in the essay on SURGICAL DISEASES OF WOMEN.

(C.) INJURIES OF THE RECTUM AND ANUS.

Incised wounds of this portion of the alimentary canal usually heal very readily. An illustration of the fact may be taken from observation of incisions made into the

[1] Med.-Chir. Trans., vol. xxxi., p. 315.

[1] See a case in Guy's Hospital Reports, 1855, p. 184.

bowel for the cure of fistula in ano, and of those in which the anterior wall of the bowel is incised, to permit the extraction of a large stone from the urinary bladder. Even instances in which the rectum has been accidentally wounded in the lateral operation of lithotomy might be mentioned, to show how readily such wounds heal.

The rectum is sometimes injured by the introduction of bougies, or the ends of enema syringes.

In the Museum at Guy's Hospital there is a portion of rectum perforated by a bougie. The patient had been affected for many years with stricture, and had often been relieved by surgical aid, at length, in an attempt to pass the bougie himself, he perforated the rectum, and death ensued in about ten hours.

In another case the same injury was inflicted by the introduction of an O'Beirne's tube. The wound was about five inches from the anus. A man, aged sixty-seven, was the subject of strangulated hernia. It was supposed to be reduced, but the symptoms of strangulation continuing, a rectum bougie was passed. Collapse and death followed. After death the rectum was found perforated, as the preparation shows.[1]

As an effect of perforation, the lower part of the abdomen may become emphysematous. A case of this kind was under the care of the late Dr. Hughes. A man, aged fifty, was admitted into Guy's Hospital in 1856, with cancerous disease of the pylorus. The necropsy revealed ulceration of the rectum, which had occupied nearly the whole of its lower third; the surface of the ulcer was irregular and ragged, and formed irregular bands and pouches. Beneath one of these bands, consisting of muscular fibre, was a small opening into the cellular tissues; this opening the patient had made with an enema syringe, and it had led to emphysema of the whole of the lower half of the abdomen. The preparation is in Guy's Hospital Museum.

As a secondary result of the wounds of the rectum and anus, peritonitis must be mentioned. If phlegmonous erysipelas attacks the wound, and extends into the connective tissue of the pelvis, the inflammation may reach the reflection of peritoneum passing from the bladder to the rectum. Spreading from this point, it diffuses itself over the whole extent of this serous membrane, and death ensues. This complication is rare, but I have witnessed its occurrence.

Wounds of this region implicating the urinary bladder have been alluded to above.

[1] The preparation is in Guy's Hospital Museum.

As an unusual result attending the operation of paracentesis vesicæ by the rectum, may be mentioned emphysema, extending to the upper part of the body.[1] This complication must be, however, very rare, since it has never occurred once in numerous operations performed in Guy's Hospital.

Foreign bodies in the rectum may be divided into two classes:

1. Those composed of materials which passed first along the upper part of the alimentary canal.

2. Those introduced at the anus.

1. To the first class belong small bones, or pieces of bone; hard bodies, as fruit stones, which may or may not be covered with accumulations of fecal matter; large bodies composed of hardened fæces; and concretions of substances taken as medicine, such as masses of magnesia.

The indications of the existence of such foreign bodies as above described are—pain in attempts at defecation; a sense of weight and fulness at the anus, as of something there which cannot pass the orifice; the habitual and often-repeated passage of loose mucous stools, occasionally a little blood; and the development of external hemorrhoids. By introducing the index-finger a hard solid mass is felt.

Such hard masses require to be removed with care. To accomplish this, the bowel must be well lubricated with oil, and warm water injected into the rectum. If these plans fail to dislodge the irritating cause, mechanical means must be employed, first to break the solid body, and then to remove it piecemeal.

2. Foreign bodies introduced per anum are of various kinds. The patient probably being always aware of the nature of the body so impacted above the sphincter ani, will be able to assist the surgeon who has to extract it, by giving some account of its structure and form. The surgeon must then exercise his own ingenuity in regard to the removal. [The reader will find in works on the Rectum (Bushe, Ashton, Quain, Curling, Allingham) and in the admirable Lectures on diseases of that organ, recently published (2d edition) by Dr. W. H. Van Buren, a number of curious and instructive cases bearing upon this subject.]

[1] Two cases are related in the Lancet, January, 1860, p. 89.

INJURIES OF THE UPPER EXTREMITY.

By W. H. Flower, F.R.S., and J. W. Hulke, F.R.S.

Revised by P. S. Conner, M.D.

One of the principal physical characteristics of man is the extensive development and varied application of the upper extremity. When we consider that it is chiefly by the wonderful power and versatility of movement enjoyed by the hand and arm, that the mandates of his intellectual nature are carried out, and its evidences impressed on the material creation, and moreover, that this member is so situated as to be constantly interposed for the protection of otherwise defenceless vital organs, it will not seem surprising that injuries are met with more frequently in this, than in any other part of the human frame. The greater number of these, of course, present no special characters which distinguish them, either in their nature or treatment, from similar injuries occurring in other parts of the body; hence it will only be necessary in this essay to treat fully of those, the particulars of which depend upon, or are modified by, the anatomical constitution of the part affected.

The frequent and comparatively slight injuries called *bruises* or *contusions*, may be met with in the upper extremity in every variety of severity, but call for no especial remark on their nature and treatment. The same may be said of the effects of intense heat and cold, *burns*, *scalds*, and *frost-bite*. The ends of the fingers are liable to the latter affection under the same circumstances as produce it elsewhere, but, as a general rule, are not so readily attacked as the corresponding parts of the lower extremity.

Sprains.

Sprains are very frequent in all the joints of the upper limb, especially in the wrist, and articulations of the thumb, as these parts are much exposed in falls, when the arms are instinctively thrown out to protect the head and chest. The bones being forcibly bent upon one another, if actual dislocation be not produced, a severe strain of the ligaments, often attended with rupture of some of their fibres, will take place. [At the wrist, not dislocation, but fracture, is likely to occur, and unquestionably many so-called sprains of this joint are fractures of the lower end of the radius, quite near the articular line.] This is not unfrequently followed by inflammation of the synovial membrane and other structures connected with the joint, sometimes of a very intractable nature. Even when the active inflammation is subdued, a relaxed and permanently weakened condition of the part will often remain. Neglect in the early period of the treatment is a frequent cause of the trouble that such injuries give rise to afterwards, it being very difficult to convince patients of the necessity of submitting to the inconvenience of keeping the joint in a complete state of rest, for what seems at first a trifling injury. The continuous application of ice (for which the caoutchouc bags recommended by Esmarch are very useful) greatly relieves the pain and cuts short the period of acute inflammation; but the ice must be constantly applied without intermission, otherwise it rather does harm, and fomentations are preferable. When the pain has abated, uniform compression of the joint with a roller or adhesive strapping will promote the subsidence of the swelling, and will allow the patient some use of the limb sooner than would be safe without this support. Stiffness, so troublesome after these injuries, is best overcome by passive movement and friction with stimulating liniments. [The early application of an immovable dressing or a rubber bandage will materially lessen the severity and duration of the symptoms of these sprains, and methodically practised massage will relieve the resulting stiffness.]

The *muscles* appear to be sometimes the seat of sprains. After violent exertion, as rowing, lifting heavy weights, etc., some particular muscle, or group of muscles, is found to be swollen, tender, or perhaps painful, especially when any movement brings it into action. Similar causes occasionally produce *rupture of the muscles*, either entirely or in part. The muscles of the upper extremity in which this has been observed, are the pectoralis major, deltoid, triceps, and more frequently the biceps.

Rupture of tendons is an accident about which much has been written, especially with reference to the long tendon of the biceps, which would appear to be especially obnoxious to this injury. Mr. Callaway[1] has fully described the symptoms attendant

[1] Dissertation upon Dislocations and Fractures of the Clavicle and Shoulder-joint, p. 144.

upon it, and has collected twenty-two cases, in which on post-mortem examination the upper part of the tendon had apparently been torn; but the researches of more recent pathologists have shown that one of the most constant effects of the not unfrequent disease of the shoulder-joint, called by Dr. R. Adams of Dublin "chronic rheumatic arthritis," is disorganization and ultimate destruction of the intracapsular portion of this tendon. In the absence therefore of any history of injury, and taking into consideration the other pathological changes which were found in the joints examined, the greater part, if not all, of the so-called cases of rupture of the longer tendon of the biceps may reasonably be supposed to have been the result of this disease.[1] [That the tendon of the long head of the biceps can be and has been ruptured, both completely and partially, is beyond question. When such laceration has taken place, as Hueter has shown, flexion of the *supinated* forearm is impossible.] In the opinion of the last-named surgeon [Adams], the reported cases of dislocation of the long tendon of the biceps with partial displacement of the head of the humerus upwards,[2] are also to be classed as the effects of disease, and not of injury; but the proof of this appears to me not quite so satisfactory as in the former cases. [Gerster, of New York (New York Med. Jour., May, 1878), says: "No surgeon ever saw the said tendon *in statu luxationis*. . . . The luxation of the long head of the biceps never was observed on the living subject in its uncomplicated form, and its existence is very doubtful."]

In connection with this subject, a curious injury may be mentioned, which has been described as *displacement of the inferior angle of the scapula* over the edge of the latissimus dorsi muscle, and is stated to be caused by raising the arm above the head to an unnatural extent. The only fully reported cases that I have been able to collect of anything analogous to this, are, one by Mr. Banner,[3] another by Mr. Rose,[4] and a third, which occurred in 1859 among the out-patients of the Middlesex Hospital, and for the particulars of which I am indebted to Mr. W. H. Rix, at that time house-surgeon. None of these cases, however, exactly correspond with the description given by Liston;[5] for although the posterior border and inferior angle of the scapula projected very markedly, there was no distinct account of any injury, and the affection seemed rather to be paralysis of the muscles attached to this part of the bone, especially of the serratus magnus. In the last-mentioned case the subject was a delicate-looking girl of fourteen; the whole of the posterior border of the right scapula was very prominent, and seemed to meet the skin covering it almost at a right angle. The inferior angle only projected a little more than the rest of the border, but the fingers could be passed fairly beneath it. The scapula could easily be pressed into the proper position, but it immediately started back again when left to itself. The motions of the arm were weakened and impaired. The treatment of such cases consists in the application of a bandage round the chest to keep the scapula in place, and galvanism to restore the tone of the affected muscles. I have seen a few similar cases. In all, the projection of the lower angle of the scapula was apparently due to atony of the muscles attached to the vertebral border of the bone, and in no instance was there a history of an antecedent injury.

[1] See R. Adams's Treatise on Rheumatic Gout, 1857, and art. "Abnormal Conditions of the Shoulder-joint," in Cyclop. Anat. and Phys.; R. W. Smith, Dublin Quarterly Journal of Medical Science, Feb., 1853; E. Canton, London Medical Gazette, 1849, vol. viii., p. 958.

[2] See a paper by J. Soden, Jr., Med.-Chir. Trans., vol. xxiv., 1841.

[3] Trans. Prov. Med. and Surg. Association, vol. xi., 1842.

[4] London Medical Gazette, vol. xlv., 1850.

[5] Elements of Surgery, 1832, part iii., p. 321.

Wounds.

The hand and arm, from their frequent exposure, are liable to every kind of wound, nearly all of which are amenable to the ordinary modes of treatment. All varieties of poisoned wounds are of course more often met with here than elsewhere, though their frequency is exaggerated, in consequence of whitlows and other local manifestations of peculiar constitutional conditions being generally attributed, by the sufferers from them, to such an origin. When, from whatever cause, suppuration has taken place in the hand or fingers, the importance of early and free evacuation of the pus cannot be too strongly insisted upon, as it is often confined beneath the dense fasciæ, and being thus prevented from reaching the surface, extends along the course of the tendons, causing extensive disorganization of all the tissues, and frequently terminating in sloughing of the tendons, or necrosis of some of the phalangeal bones.

According to M. Nélaton, abscesses of the forearm develop themselves most commonly after wounds or inflammations of the thumb, or little finger, "rarely after wounds of the other three fingers; and the anatomy of the parts, which shows that the sheaths of the flexors of those fingers do not communicate with the sheath under the annular ligament under the wrist, explains the reason."[1] The same surgeon also remarks, that in examining for pus in this part, it is necessary to make palpation in the long diameter of the limb; as, if the fingers are placed transversely, the sensation caused by the displacement of the muscles is very deceptive. If the abscess

[1] Clinical Lectures on Surgery, edited by Walter F. Atlee, M.D. Philadelphia, 1855.

is deeply seated, in order to obtain a free opening, and to avoid wounding nerves, vessels, or tendons, M. Nélaton directs that an incision should first be made through the skin three inches in length, then the aponeurosis slit open upon a director over an interstice between two muscles; the latter may then be separated, and the opening enlarged, if necessary, by introducing the end of the finger. [Hilton's well-known method of opening deepseated abscesses (see ante, p. 337) may be advantageously resorted to.]

Needles often run into, and break off in, the hand, causing sometimes much trouble in extraction, especially if the piece be small, and have penetrated deeply into fleshy parts, as the ball of the thumb. The position of the foreign body must be ascertained as well as possible, by searching for the wound by which it entered, and by carefully feeling for its ends through the skin. If its situation can be ascertained with tolerable certainty by these means, it must be cut down upon, and drawn out with the forceps; but care must be taken not to drive it farther in during the attempt at extraction, and all unnecessary or speculative incisions in a part so well supplied with nerves and vessels as the palm of the hand must be avoided. Time and some suffering is saved to the patient, if it can be found and extracted at once; but if, after a thorough examination, it cannot be discovered, we must wait until it shifts its situation and it can be felt, allaying the inflammation and pain with poultices and anodynes.

Lacerated wounds about the hand are the cases commonly supposed to be especially liable to be followed by tetanus; yet I think that if we examine the assigned causes of many cases of traumatic tetanus, allowing for the great comparative frequency of such injuries, we shall hardly find that wounds of the hand bear any disproportionate ratio to those of other parts. [Of twenty-six cases of tetanus reported by Dr. William Hunt as under treatment in the Pennsylvania Hospital (Surgery in the Penna. Hospital), only three followed hand-injuries.]

In incised and punctured wounds inflicted by carpenters' tools or knives accidentally slipping from the hand, or by broken glass, the radial or ulnar arteries are not unfrequently divided near the wrist; but the treatment will be conducted entirely in accordance with the general principles applicable to the wounded arteries. (See pp. 453 et seq.)

The bleeding from wounds of the deep palmar arch is apt to be very troublesome, on account of the difficulty often experienced in finding the divided extremities of a vessel placed at a considerable depth from the surface, close to the bone, and in a wound which, owing to its anatomical relations, cannot be freely enlarged. Therefore, in this case it is necessary sometimes to depart from the rule, almost universal elsewhere, of tying the vessel at the seat of the injury, and to seek some other method of restraining the hemorrhage. In the first place, a graduated compress should be laid over the wound: this is kept in position by two small wooden splints placed transversely across the hand, one on the palmar and one on the dorsal side, a good pad of lint being placed beneath the latter, while the former rests upon the compress; they may then be brought together to any degree of tightness, by strips of adhesive plaster round their extremities. Then the current of blood through the radial and ulnar arteries should be restrained, either by pieces of thick bougie, or by small rollers laid lengthwise over the course of the vessels in the lower part of the forearm and confined by a bandage. A third larger roller, placed between the others, is often a useful adjunct in keeping these in place, by preventing the bandage from forcing them towards each other. Extreme flexion of the elbow, which checks the flow through the brachial artery, is preferred by some surgeons. The patient should, if possible, be kept in bed, with the hand raised high above the level of the rest of the body. If secondary hemorrhage come on, the compress must be taken off, the wound well cleaned from clots, etc., and the apparatus readjusted. Close observation of each case alone will teach to what extent, and for how long, pressure may be applied to the wound without fear of producing sloughing of the tissues. This so generally occurs when the wound has been plugged with compresses, wetted with the strong acid solutions of the persalts of iron now in common use, that the practice cannot be recommended. If these means fail to stay the bleeding, ligature of the arteries of the forearm in their lower third, or of the brachial a little below the middle, must be adopted. Opinions are much divided as to which is the preferable operation. Most surgeons use the latter only as a *dernier ressort;* while others, finding that if both radial and ulnar are tied, circulation in the hand is still maintained by the interosseous artery, which is secured with difficulty, prefer the single and simpler proceeding of at once tying the brachial. My own experience, drawn from the observation of several cases, is in favor of tying the radial and ulnar arteries just above the wrist, unless the forearm is greatly inflamed and swollen. [Properly applied compression, either graduated or by the elastic bandage, will stop the bleeding in the majority of cases of wound of either of the palmar arches. When it fails to do so, it seems the wiser course (in

view of the free anastomosis between the branches of the radial, ulnar, and interosseous arteries, and the dangers of recurrent hemorrhage after ligations of the brachial) to apply the Esmarch bandage, to by careful dissection find the bleeding point, and to tie the vessel on both sides. If it is the deep arch that has been wounded, it may prove necessary to resect the base of one or more metacarpal bones in order to get at the vessel; but even this is preferable to a higher ligation that may not control the hemorrhage. The use of the persalts of iron in wounds of the palm not only "cannot be recommended," but cannot be too strongly condemned.]

Severe lacerated wounds, with or without fracture, as well as wounds of joints, should be treated according to general principles, recollecting, however, that such injuries are endured and recovered from, far more readily in the upper, than in the corresponding parts of the lower extremity. Not only is the reparative power more active, but there is also the advantage of their not requiring the patient to be confined to bed, with consequent deterioration of general health, during the whole of the treatment. Numerous instances of most severe compound fractures and dislocations implicating the elbow or wrist-joint, which at first sight appeared hopeless, have by careful treatment completely recovered.

The records of military surgery will furnish many such. As a good example of the extent of reparative power, when aided by judicious treatment, I may quote one related by Sir James Prior, Deputy-Inspector of Hospitals and Fleets,[1] which occurred in civil practice. A man, aged thirty-four, working in a dockyard, received a violent blow from the rapidly revolving handle of a windlass, on the under side of the left arm, at the elbow-joint. "There was a large wound on the under surface of the joint, occasioning a general disconnection of its parts, muscular and otherwise, excepting immediately in front. All the ligaments also were obviously torn asunder; the heads of the radius and ulna were driven wholly from their situations, upwards and forwards on the humerus; the condyles of the latter bone, and part of its shaft, to the extent of two and a half or three inches, projected behind from the wound at nearly a right angle with the forearm, and as thoroughly denuded of all ligaments and muscular attachments as if cleaned with the scalpel." The brachial artery and nerves of the arm being uninjured, it was determined to attempt to save the limb. The bones were easily reduced, the wound carefully brought together, and treated with cold applications. The patient eventually recovered with a very efficient limb, and went back to his laborious employment.

Primary amputation is very rarely required in cases of compound fracture or dislocation involving the elbow-joint—never, indeed, unless the artery be torn through, or the soft parts in front as well as behind the joint extensively damaged. In treating such injuries, the position most favorable and convenient to the patient, that of semiflexion, should be adopted, the arm being fixed immovably on a gutta-percha splint [or plaster-of-Paris], which may be cut away, opposite the wound, so as to allow of the application of the dressings; and the fracture or dislocation being reduced, and any loose fragments of bone removed, the wound should be thoroughly washed with a solution of chloride of zinc or carbolic acid; its edges should be brought together as neatly as possible with wire sutures, and treated with cold applications, especially ice, if there be much inflammatory action. When the bones are much comminuted, and the external wound is small, it is best to enlarge it freely, and excise the injured ends of the bone, as much less constitutional disturbance follows cases so treated, and a false joint with a very considerable amount of motion will be formed.[1] Wounds of the wrist-joint should be treated on the same principles, the forearm and hand being fixed upon a straight splint.

Compound fracture of the humerus, if attended with much laceration of soft parts, especially lesion of the artery, and of the great nervous cords, sometimes requires amputation; but the forearm when similarly injured may almost always be preserved.

The hand is very frequently the subject of extensive crushes, involving bones as well as soft parts, and often requiring the removal of one or more of the fingers or of the whole member. Great ingenuity may be displayed in the performance of the operation in such cases, the surgeon being guided in the amount to be removed and the selection of flaps by the extent of the injury, always remembering the necessity of saving as much as possible. The loss of one or two fingers is not of great moment, except in some peculiar occupations; but the thumb is of especial importance, and if only a single finger is left to oppose it, great use may still be made of the hand. It is even better to save the thumb alone or a single finger when it can be done, than to sacrifice the whole hand. Although everything that is likely to be of service must be carefully preserved, the opposite error must be avoided of attempting to save, at a great sacrifice of time to the patient, a severely injured finger, which, although it may ultimately heal, will remain permanently stiff or deformed,

[1] Lancet, December, 1844.

[1] See an interesting series of severe injuries to the elbow-joint, in London and Provincial Hospitals, collected by Mr. J. Hutchinson, Medical Times and Gazette, 1856, vol. ii.

and which, from its being either useless or positively interfering with his employment, may eventually have to be removed. Among people of the upper classes of life, even elegance of appearance is an element of consideration. On the latter account, when a finger has to be removed entire, the head of the metacarpal bone, although uninjured, is often taken out with it, so that the remaining fingers come nearer together, and the loss is less conspicuous; but with working people, this should not be done, as to them a broad palm is often an advantage; and the hand is weakened by the division of the transverse ligament which connects the head of the bones. In compound dislocations of the phalanges, in which attempts at reduction have been unsuccessful, it is better to remove the projecting head of the displaced bone, then to bring the wound together, and fix the finger on a splint, trusting to the formation of a ligamentous joint. [In the great majority of cases of injury of the hand, primary amputation should not be made, all cutting operations being deferred until after it has become apparent just how much must be removed.]

Statistics of Fractures and Dislocations of the Upper Extremity.

Nearly all statistical information hitherto published regarding fractures and dislocations is more or less unsatisfactory, either because the numbers given are too limited, or the cases being selected, they do not present a fair average of all ages and classes of the population.

The following table has the advantage of showing nearly every case which presented itself during a given period at a hospital so situated as to afford a fair example of the ordinary accidents of civil life in this country. Some few have been rejected on account of insufficiency of diagnosis, or omission of age or sex from the record, and doubtless the remainder are not entirely free from errors; such errors, however, correct themselves when the numbers are sufficiently large. In one class only is there a considerable defect, viz., the fractures of the phalanges; many cases that are vaguely entered in the hospital books as "smashed" or "crushed" fingers, without specification of lesion to bone, having been omitted from the table. If all these were added, the numbers assigned to this injury would probably be doubled.

It is not within the scope of a work like the present to discuss all the inferences that might be derived from the study of this table. A few general observations on the influence of sex and age upon the production of these injuries, will, however, be admissible.

It will be seen, as might be expected from the difference of habits and occupation, that the whole number of males exceeds that of females, the ratio being that of 10 to 6.2; but this ratio is not constant in all kinds of injury, and all periods of life. During infancy there are 200 males and 197 females; so that, as might be supposed, in this period the liability to these accidents is the same in both sexes. This age is characterized by the great frequency of fracture of the clavicle, more than half of the entire number of injuries belonging to this bone. The bones of the forearm and humerus follow next in order; but fractures of the olecranon, metacarpus and phalanges, and all dislocations, are almost unknown. During the succeding ten years we find the active disposition of boys exposing them to frequent fractures of the clavicle, humerus, and forearm, and to dislocation of the elbow-joint; while with the opposite sex such accidents are comparatively less frequent than at any other period, the proportion being now as 10 to 2.7. In the next period, that from fifteen to twenty years, the males exceed the females in the proportion of 10 to 3.7, and this excess steadily decreases, till, between forty-five and sixty, the sexes figure in nearly equal numbers; and beyond that age the liability to these accidents is considerably greater among women than among men, this preponderance being almost entirely owing to the great frequency among the former of fracture of a particular part of one bone, viz., the lower end of the radius.

Further reference to the numbers in the table will be found under the head of each particular injury.

Fractures and Dislocations of the Bones of the Upper Extremity, treated at the Middlesex Hospital, during sixteen years, ending June 30, 1867.

A. Fractures.

	Age. 0 to 5.		Age. 5 to 15		Age. 15 to 30.		Age. 30 to 45.		Age. 45 to 60.		Age. Above 60.		Total.		
	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	M. and F.
Scapula,	5	3	3	...	1	1	11	6	7	...	1	1	28	11	39
Clavicle,	176	171	84	47	56	26	67	33	51	33	18	10	452	320	772
Humerus — Upper end,	1	4	7	2	5	...	11	5	8	4	5	8	37	23	60
Humerus — Shaft,	39	22	42	17	27	18	25	16	11	16	6	15	150	104	254
Humerus — Lower end,	8	4	46	3	14	2	2	2	5	1	1	1	76	13	89
Olecranon,	1	...	7	2	23	3	14	5	8	4	4	5	57	19	76
Ulna (excluding Olecranon)	8	7	19	1	7	6	19	10	13	10	2	5	68	39	107
Radius alone,	62	64	92	19	78	45	75	57	45	123	21	87	373	395	768
Ulna and Radius,	20	17	71	11	15	7	8	9	9	12	4	8	127	64	191
Carpal bones,	...	...	...	...	...	...	1	...	...	...	...	...	1	...	1
Metacarpal bones,	1	1	10	1	62	9	50	13	15	3	3	...	141	27	168
Phalanges,	3	2	44	7	47	8	32	13	24	5	4	1	144	36	180
Total,	324	295	425	110	335	125	315	169	196	211	69	141	1654	1051	2705

B. Dislocations.

	Age. 0 to 5.		Age. 5 to 15.		Age. 15 to 30.		Age. 30 to 45.		Age. 45 to 60.		Age. Above 60.		Total.		
	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	Sex. M.	F.	M. and F.
Clavicle,	1	...	2	1	4	...	2	1	2	1	2	...	13	3	16
Acromion,	...	...	1	...	3	...	3	1	3	1	...	...	10	2	12
Humerus,	1	2	1	1	24	9	63	21	42	34	36	28	167	95	262
Elbow,	...	1	43	5	8	3	8	3	2	...	...	...	61	12	73
Thumb,	...	1	11	3	18	3	23	11	15	10	3	1	70	29	99
Phalanges of fingers,	...	...	6	2	11	3	6	11	7	7	3	3	33	26	59
Total,	2	4	64	12	68	18	105	48	71	53	44	32	54	167	521
Fractures and dislocations,	326	299	489	122	403	143	420	217	267	264	113	173	2008	1218	3226

Fractures of the Bones of the Upper Extremity.

Fractures of the Clavicle.

The clavicle is more frequently broken than any other bone in the body, the radius excepted. Although met with at all ages, this accident is most common in infancy and early childhood; nearly one-half of the entire number of cases recorded in the above table occurred before the completion of the fifth year.

Up to this period its relative frequency in the different sexes is nearly equal; at all subsequent ages men are much more liable to it than women.

Sometimes the fracture is caused by direct application of force to the bone, as by a heavy blow, or a wheel passing over it, or a fall in which the body of the bone comes into contact with some hard sub-

stance; but much more commonly it is due to indirect violence, as falls on the point of the shoulder, or on the hand when the arm is outstretched; in the latter case the shock is transmitted through the other bones to this, the last in the series, which being fixed at its proximal end to the sternum, must give way under a sufficient amount of force. Dr. F. H. Hamilton[1] has collected seven, and Gurlt twenty cases of fracture of the clavicle from muscular action.[2] [Many of these cases are probably open to the explanation that the lesion was the result of leverage, the clavicle being as it were bent over the first rib.] The last author has also brought together seven cases of intra-uterine fracture of the collar-bone produced by external violence.[3]

The bone is generally broken near the middle, although it may be towards the acromial, or more rarely the sternal extremity. The line of fracture is said to be usually transverse, but in many specimens that I have examined in museums, it has passed in a straight line from the deepest part of the cavity of one curve to that of the other, and therefore very obliquely across the shaft of the bone, and inclining from within upwards, so that the inner fragment overlaps the other. The part between the two curves is generally the weakest part of the bone, and hence more liable to fracture. When the clavicle is broken near its middle, the inner fragment is usually retained in its place, because the strong ligaments attached to its sternal end prevent much movement, and the muscles connected with it nearly counterbalance each other. There is, however, a slight tendency to elevation of the outer end, which in cases left long neglected becomes very marked. I lately saw a girl, aged nine, who had broken her clavicle a month before, and had had no treatment; the sternal fragment projected upwards at an angle of 45°, its sharp extremity forming a visible prominence in the side of the neck. The other fragment was fully an inch below this, and connected with it by what appeared to be a band of fibrous tissue, passing nearly vertically between them.[4] The outer fragment usually falls below its normal position, owing to the weight of the arm, and it is drawn inwards by the muscles passing from the chest to the shoulder and humerus, the outer end being turned somewhat forwards; its broken end is, in the great majority of cases, placed beneath that of the sternal fragment, though it occasionally, but very rarely, is found above[1] or anterior[2] to it. If the fracture is oblique, the fragments generally ride, and the whole bone is somewhat shortened. The diminution in length of clavicles that have united after oblique fractures is sometimes more than an inch.

The signs usually presented are very characteristic, and except in the case of young fat children, there is rarely much difficulty in the diagnosis. There is pain at the seat of injury; the patient is unable to lift the arm to the head, or to move it extensively forwards or backwards, at least without much suffering; his neck and head are usually inclined to the injured side; while, to relieve the pain caused by the displaced fragments of bone, he will often support the elbow with the opposite hand. The point of the shoulder falls lower than the other, and somewhat forwards and inwards, its distance from the centre of the sternum being diminished in proportion to the amount of riding of the broken fragments. On passing the finger along the upper border of the clavicle, the abrupt projecting end of the inner fragment and the depression of the outer one are easily recognized, and manipulation will prove the separation of the fragments, and generally produce crepitus, though the latter important sign is sometimes not perceived until the broken ends are brought into apposition by extending and drawing back the shoulders. The differences in position of the bone mentioned above will of course produce corresponding modifications of these signs. In transverse fractures, the amount of displacement is often inconsiderable; but pain, loss of power, mobility of the fragments, and crepitus will indicate the nature of the injury.

[In young children, when the fracture is incomplete or the fragments are held together by untorn periosteum, the only symptom at first discoverable may be tenderness on pressure over the seat of injury, "the line of limited tenderness;" later, color-changes of the skin, due to extravasation of blood, will show themselves. If the nature of the injury is not recognized and proper treatment instituted, the probabilities are that within a very few days the periosteum will be completely torn and the ordinary symptoms become apparent. Attention should here be called to the change that takes place in the position of the scapula, the inferior angle of which is approximated to the spine and abnormally prominent. As has been shown by many writers (especially of late by Drs. Packard and

[1] A Practical Treatise on Fractures and Dislocations, p. 193, Philadelphia, 1880 [6th ed.].

[2] Gurlt, Handbuch der Lehre von der Knochenbrüchen, Th. 2, L. 2, p. 593 et seq.

[3] Gurlt, loc. cit., Th. 2, L. 2, pp. 595–6.

[4] See also the figure at p. 219 in Dr. R. W. Smith's Treatise on Fractures in the Vicinity of Joints, etc. Dublin, 1847.

[1] Malgaigne, Traité des Fractures et des Luxations, tome i., p. 468. Paris, 1847.

[2] Lonsdale, Practical Treatise on Fractures, p. 208, 1838.

Hartshorne, of Philadelphia), the correction of this scapular displacement relieves the deformity at the seat of fracture. Dr. Edward Hartshorne (Penn. Hosp. Reports, vol. ii., 1869) urges the use of a back-splint, making pressure "directly upon the lower blade of the scapula about and just above its angle, behind the chest." To the pressure made upon the scapula the same writer attributes the favorable results of the "posture method," *i. e.*, the keeping the patient upon the back in bed.]

Fracture of the sternal extremity of the clavicle is a very rare accident. Lonsdale,[1] relating the case of a child three years old, in which the clavicle was fractured about half an inch from the sternum, conjectures that such cases arise from separation of the epiphysis. This, however, clearly cannot be, as the epiphysis at the sternal end of the clavicle is an extremely thin plate of bone, and commencing to ossify at about the age of eighteen, is joined to the bone a few years later; if, then, such an injury could happen, it would be only at this particular period of life. Blandin[2] describes a case in which the clavicle was fractured between the costo-clavicular and sterno-clavicular ligaments, without displacement; but in the only two specimens of similar fracture that Malgaigne[3] could find in the Musée Dupuytren, the external fragment was displaced considerably downwards and forwards.

Two examples of this accident recently occurred at the Middlesex Hospital. Both patients were girls under ten. In one the fracture, produced by indirect violence, was about half an inch from the sternal joint, and the displacement was very slight; in the other the fracture, caused by direct violence, was a little further from the sternal joint and there was more displacement.

Fig. 174.

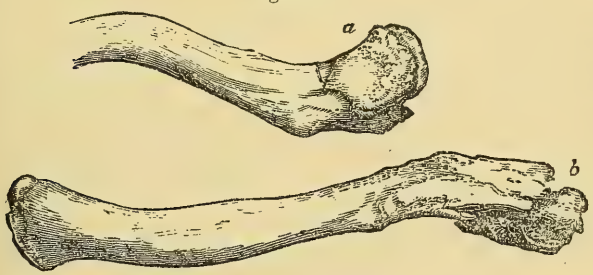


FIG. 174. Extremely oblique fracture of the acromial end of the clavicle. *a*, under surface; *b*, anterior view. From a preparation in the Middlesex Hospital Museum; Cat. No. 1., 15, d.

Fractures of the acromial extremity of the clavicle are much more frequent than the last. R. W. Smith[1] has shown, from examination of specimens of bones after death, that the outer end of the clavicle may be broken, either between the conoid and trapezoid portions of the coraco-clavicular ligament, or between this ligament and the acromio-clavicular articulation. In the former situation the fracture is of comparatively rare occurrence, and attended with scarcely any displacement of either fragment of the bone; in the latter, on the contrary, there is generally a considerable amount of displacement of the outer fragment; its inner end being drawn upwards and outwards by the action of the clavicular portion of the trapezius muscle, while the outer or articulating surface is directed downwards and inwards by the weight of the arm and the action of the muscles passing from the chest to the shoulder. This displacement is sometimes carried so far that in some of the cases examined, the outer fragment had united to the other at a right angle.[2] The inner fragment is not materially altered in position, unless the coraco-clavicular ligament be ruptured.

An *incomplete fracture* of the body of the clavicle, sometimes attended with *bending* of the bone, is occasionally met with in children. Vide FRACTURES, p. 484.

Comminuted fractures of the clavicle are not unfrequently the result of violence, and are easily recognized by the great mobility of the fragments.

Compound fractures of the clavicle are extremely rare [it might almost be said that they never occur except as the result of gunshot wounds, so rarely are they consequent upon injuries of other kinds]; and notwithstanding its vicinity to the large vessels and nerves of the neck, serious complications from implication of the soft parts do not often follow fractures of this bone.

Among the severe injuries which occasioned the death of the late Sir Robert Peel, was "a comminuted fracture of the left clavicle, below which a swelling as large as the hand could cover, and which pulsated synchronously with the contractions of the auricles of the heart, formed." This was evidently the result of a wound of some large vein, probably the subclavian, by the broken ends of the bone. From the intense pain suffered, it was also

[1] Op. cit., p. 206. .
[2] Gazette des Hôpitaux, 22 avril, 1845.
[3] Op. cit., tom. i., p. 491.

[1] Op. cit., p. 209.
[2] This observation is corroborated by a recent specimen exhibited by Mr. Canton to the Pathological Society, Nov. 6th, 1860.

conjectured that some of the nerves of the axillary plexus were lacerated.[1] In the Museum of St. George's Hospital is a specimen in which the fractured end of the bone was driven through the internal jugular vein. The patient, a boy aged thirteen, had been standing under a tree in a storm, and was struck by a falling branch. Several cases are also on record of injury to the brachial plexus of nerves, followed by paralysis of the arm.

Fracture of both clavicles in the same subject sometimes occurs. [Hamilton regards them as much more common in children and in private practice than in adults and in hospital patients.] Malgaigne could only collect five cases. A man, aged forty-seven, was admitted a few years ago into the Middlesex Hospital with ununited fracture of both clavicles, occasioned by the same injury. Want of union is very uncommon; in this case it was probably owing to the difficulty of restraining the motion of both

Fig. 175.

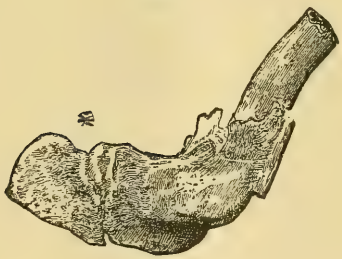


FIG. 175. An extremely oblique comminuted fracture of the acromial end of the clavicle; under surface. The asterisk points to the acromio clavicular joint. From a preparation in the Middlesex Hospital Museum; Cat. No. i., 15, d. (See FIG. 182.)

arms at the same time during the treatment; as a general rule, no bone in the body unites more readily. [From the body of a man who died in the Charity Hospital, New Orleans, La., in 1864, I removed a right clavicle which had been broken in two places, the union being ligamentous at both.] In 1867, a young girl was brought to the Middlesex Hospital with both collar bones and some ribs broken. She was kept flat on her back in bed for some days, and made a good recovery.

Treatment.—Although the indications to be followed in the treatment of fractured clavicle are plain enough, the numerous contrivances that have been invented for the purpose, and the diversity of the methods adopted in different countries, and by different surgeons, are sufficient to show the difficulties that are practically found in carrying them out. As Dr. F. H. Hamilton says, "a catalogue of the names only of the men who have upon this single point exercised their ingenuity, would be formidable, nor would it present any mean array of talent and of practical skill."

The most certain method to insure union without deformity, is to keep the patient lying on the back in bed until the fracture has united, the head being fixed to the pil-

Fig. 176.

FIG. 176. The upper surface of the same preparation. The inner fragment overrides, and the outer has been twisted so as to make a considerable angle with it.

low, and both arms confined to the side of the body. This plan may be adopted in the case of young ladies who wear low dresses, and in whom it is consequently particularly desirable to preserve the symmetry of the clavicles; but men and boys will seldom be found to submit to the confinement, and it is satisfactory to know that the amount of shortening which almost invariably follows an oblique fracture, treated in the usual way, will rarely interfere in any appreciable degree with the perfect use of the arm.

Presuming that the ordinary displacement has occurred, to restore the outer fragment to its normal position, the shoulder must be drawn outwards, upwards, and backwards. For a description of the many, more or less complicated, forms of apparatus invented to retain the parts in this position, the reader is referred to special treatises upon the subject, as they have nearly all met with but a very limited or local application, and without figures any account of them would be unintelligible. As the results of the method of treatment generally followed at most of the hospitals in London are as satisfactory as those attributed to any of the others, and as there is in it the great advantage of requiring no other materials than those which are at all times at the command of the surgeon, I shall content myself with describing it. A stout wedge-shaped pad, with the broad end upwards, stuffed with tow or horse-hair, and having a little cotton-wool wrapped around it, is placed well up in the axilla. Then the elbow is brought close to the side, and the forearm laid across the front of the chest, the hand being raised towards the opposite shoulder.

[1] Lancet, July 6th, 1850.

It is now to be firmly bound in this position with a broad calico roller, some of the turns of which are made to pass beneath the elbow and over the opposite shoulder, so as to act as a sling, and raise the humerus. The bandages should be secured by a few stitches.[1] Some surgeons advance the elbow, others think it should be directed somewhat backwards. But an intermediate position is more generally preferred. Very frequently, before the elbow is fixed, a figure-of-eight bandage is placed round the shoulders, and tied tightly behind, with the intention of drawing backwards the extremity of the clavicle; but this is by many, and with much justice, objected to, on the ground that, unless put on with very great care, it may press upon the inner end of the distal fragment and push it behind and below the other, thus adding to the deformity which it is intended to prevent. The axillary pad, which was introduced by Desault as a fulcrum by which the clavicle may be extended when the elbow is pressed to the side, is now generally used of a smaller size than was originally proposed, and is discarded altogether by some surgeons, on account of its liability to compress the axillary vessels and nerves. The apparatus is then reduced to little more than a sling for the elbow.

[In many cases, keeping the forearm behind instead of in front of the body (the "Broca method") will be found to cause comparatively little inconvenience to the patient, and to be followed by very satisfactory results. Sayre's method of applying a strip of adhesive plaster (4 to 6 inches wide) "across the belly of the biceps around the back of the arm, bringing the arm well back, horizontally across the back and around under the nipple," with associated support of the elbow, has been a favorite mode of dressing with many American surgeons, on account of its simplicity and the ready tolerance of it by the patient.]

It is evident from these differences of opinion, that in the management of fractured clavicle, as in that of any other similar injury, no one rule ought to be followed. Careful attention to the peculiarities of the individual case will alone suggest the particulars of the treatment that should be adopted; and whatever may be the apparatus determined upon, it should be frequently examined, in order to be sure that the intention with which it is applied is really being carried out, and that no parts of it have become loose or disarranged, or, on the other hand, are unnecessarily tight, so as to give pain or chafe the skin.

If the fracture is attended with complications, or if both clavicles are broken, it is advisable to confine the patient to bed.

Union usually takes place in about three weeks—in young subjects even earlier.

Fractures of the Scapula.

As this bone is not, like the clavicle or other long bones of the arm, placed between resisting points, it is not often affected by any application of indirect violence; and as its peculiar conformation and protected situation afford it considerable immunity from direct injury, it is very rarely broken. The statistics of the Middlesex Hospital for sixteen years (table on p. 845) give 1.07 per cent. as the relative frequency of fractures of the scapula, which agrees closely with that given by Gurlt. [Among 4939 fractures reported from the Pennsylvania and Boston City Hospitals 59 were of the scapula, 1.2 per cent. nearly.] The shape of the scapula is so very irregular, that fractures occurring in its different parts present special characters, and require therefore separate consideration.

1. *Fracture of the body of the scapula* may occur in combination with other injuries when the trunk is severely crushed, as by the fall of a heavy weight upon it. It has also been caused by a blow applied directly, the passage of a cart-wheel over it, or a fall backwards, in which the bone is struck against some hard substance, such as the corner of a table.

The fracture usually runs transversely or obliquely across the flat part of the body of the bone beneath the spine; but sometimes it extends vertically through the spine, or the bone, which in other instances is variously starred or comminuted. An incomplete fracture through the spine alone, or one of the margins, appears to be sometimes met with; and occasionally the thin central portion of the infra-spinous fossa is fissured, or even deeply indented, while the borders, being thicker and stronger, have escaped injury. There is often but little displacement of the fragments; sometimes, however, one or the other of the broken edges may be felt to project. In a man aged forty-three, lately a patient at the Middlesex Hospital, the body of the scapula was broken by a carriage-wheel passing over his back; he was so extremely thin, that the nature of the injury could be ascertained with perfect facility. The line of fracture extended from the anterior costa, one inch above the inferior angle, upwards and backwards to the posterior costa, just below the root of the spine. The triangular portion thus separated was drawn directly upwards under the other, and became united there; so that the scapula was eventually one inch

[1] Bandages stiffened with starch, dextrine, or plaster-of-Paris, are often used with great advantage.

shorter than the other, and had the lower end deeply notched. There is a specimen in Guy's Hospital Museum[1] in which the line of fracture is almost the same, but the inferior fragment has united on the dorsal surface of the other. The different direction of the displacement of the fragment in these instances was probably communicated to it at the moment when the injury was inflicted, while the drawing upwards was due to the combined action of the muscles attached to it.

Mobility can generally be detected by grasping the shoulder and upper part of the scapula with one hand, and the lower part of the bone near the inferior angle with the other; crepitus will also be obtained in this manner, or by placing the

Fig. 177.

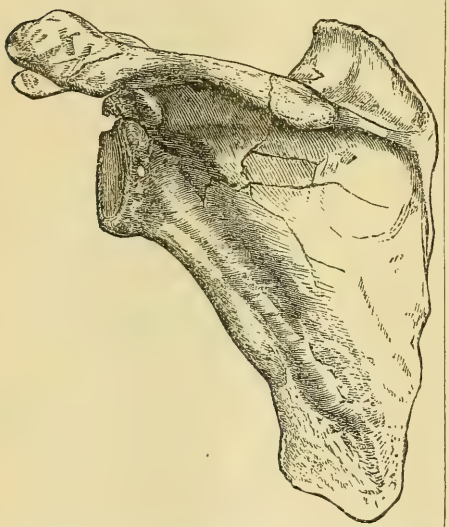


FIG. 177. Fracture through the glenoid cavity, running into the body, and crossing the spine of the scapula; with fracture of the acromion process. From a preparation in the Middlesex Hospital Museum; Catalogue i., 17. No history is attached.

hand flat upon the dorsum of the scapula, and moving the humerus in various directions. But great care must be taken not to mistake that pseudo-crepitus which appears to be caused by the movement of the tendons over the shoulder-joint for a bony crepitus; a mistake not unfrequently made by experienced surgeons when examining injuries about the shoulder. In muscular and fat subjects, and where there is little displacement, the diagnosis of these fractures is often attended with difficulty, but in others the signs are sufficiently obvious. Malgaigne recommends that in making the examination, the forearm should be brought behind the back, and the hand raised as much as possible, as by these means the inner border of the scapula will be rendered prominent.

Treatment.—The fragments having been reduced as completely as possible by manipulation, the body of the scapula should be confined by a shield of gutta-percha modelled to it, or with a broad bandage or strip of adhesive plaster [or better with plaster-of-Paris]. The motions of the arm are then to be restrained and the elbow raised, by supporting it in a sling. When there is much displacement, it is difficult to keep the fragments in good apposition by the application of compresses, or any of the other contrivances that have been suggested for the purpose; but in most cases union takes place readily, and although there may be some deformity, the arm regains its proper motions.

2. *Fracture of the acromion process.*—The acromion process being the most prominent part of the shoulder, it is liable to be broken across when a blow is received directly from above, in falls upon the shoulder, and also perhaps by upward pressure of the head of the humerus, in falls on the elbow or hand. The frequency of this accident has been overrated, as many of the numerous specimens found in museums of what appear at first sight to be old ununited fractures of the acromion, are probably examples of non-union of the epiphysis.[1] There seems to be some as yet unexplained connection between this condition and the disease called chronic rheumatic arthritis of the shoulder-joint, as they are often found associated.[2] For this reason, little dependence can be placed upon the statement, founded on the examination of such specimens, that after fractured acromion the union is always of a ligamentous character.

The fracture usually extends directly across the process, separating a larger or smaller portion from the rest of the bone. Sometimes it is only the extreme tip beyond the clavicular articulation which is broken off. Occasionally there is no displacement, the detached fragment being held in its place by the periosteum, but generally it is drawn downwards and a little forwards, by the action of the deltoid and weight of the arm.

The symptoms are, pain in the injured part, with loss of power in moving the arm, especially upwards. The shoulder has lost somewhat its rounded form, its extremity being sunk. On passing the finger along the spine of the scapula towards the acromion, a sudden depression is felt at the seat of fracture, and mobility of the process itself can be perceived. On raising the

[1] No. 1097[70].

[1] F. H. Hamilton, op. cit., p. 211.
[2] R. Adams, op. cit., p. 107.

arm so as to bring the fragments in apposition, all the abnormal appearances are lost, and crepitus, which is absent as long as the arm hangs down, can now be obtained.

Treatment.—The principal indication is to support the elbow, so that the acromion may be raised by the head of the humerus; this is accomplished by a sling, which must be made to give more support to the elbow than to the forearm, allowing the hand to drop. More perfect apposition can be obtained if a pad be placed between the side and the elbow, so as to keep the latter away from the body, and inclined a little backwards. The arm should then be fixed by a roller passed round the chest, and kept in this position for about four weeks.

3. *Fracture of the coracoid process* is an extremely rare accident, and only produced by severe direct violence; it is usually accompanied by other injuries, as dislocation of the humerus in the cases reported by South[1] and Holmes,[2] or by fracture of other parts of the scapula. If the coracoid process alone is broken off, the three muscles attached to its extremity would tend to draw it downwards and inwards; but while the strong coraco-clavicular ligaments remain entire, the displacement cannot be very great. In an uncomplicated case, there is no alteration in the shape of the shoulder, the principal diagnostic signs being crepitus and the mobility of the fragment, discovered by manipulation.

Two cases of fracture of this process have come under my own notice. In both, the fracture was caused by a fall forward from a slight height with the arms stretched forward; there was mobility of the tip of the process, with crepitus and pain, but not any displacement.

The treatment consists in supporting the arm in a sling, with the elbow advanced upon the front of the chest, so as to keep the muscles inserted into the process relaxed, and as much at rest as possible.

4. *Fractures of the neck of the scapula, and of the glenoid fossa.*—It is the opinion of most modern writers on surgery, that simple fracture across the anatomical neck of the scapula never occurs.

There is no specimen exhibiting it in any of the museums in London, and Hamilton says that he has not been able to find one in any of the American cabinets. There are several cases on record of fracture through what has been called the surgical neck, *i. e.*, the narrow part of the bone, opposite the notch in the superior costa, the coracoid process being included in the separated portion. In all of those with which I am acquainted, there has been also a general comminution of the body of the bone. One specimen is in the Museum of Guy's Hospital;[3] another, in which repair has taken place, in the Museum of the Royal College of Surgeons; and the well-known case reported by Du Verney,[1] where the injury was occasioned by a fall into a stone-quarry, forms a third example. The three cases related by Sir Astley Cooper, and various others, which have appeared more recently in the journals, of "fracture of the neck of the scapula," were founded only on diagnosis made during life. They are, therefore, not entirely to be relied upon, especially as it has been shown by Malgaigne that most of the symptoms usually assigned to this injury might be produced by a dislocation of the humerus into the axilla, with fracture of a portion of the margin of the glenoid fossa.

The last-named accident is not very uncommon: the inner border is more frequently the seat of injury, but fractures have been found running across the glenoid fossa, and even splitting it up into several portions. In a case which I believed to be one of this kind, admitted June 25, 1860, into the Middlesex Hospital, there was a distinct bony crepitus accompanying subcoracoid dislocation of the humerus. The latter when reduced almost immediately reappeared, and as the spasm of the muscles by which this was occasioned increased after every reduction, it constantly became more difficult to replace the bone, and when replaced to keep it in position. The patient was then brought completely under the influence of chloroform, a large pad fixed in the axilla, and the elbow bound close to the side and raised. By these means the humerus was retained perfectly in place, and no subsequent difficulty was experienced during the treatment. At the end of three weeks the bandages were removed, and passive motion commenced in the joint.

Fractures of the Humerus.

The fractures to which this bone is liable may be conveniently divided into three groups, viz.: (A) those affecting the upper extremity, or that part which is situated above the surgical neck of the bone; (B) those of the shaft; and (C) those of the lower articular extremity.

The injuries belonging to the first group, although of less frequent occurrence than either of the others, demand the fullest attention of the surgeon, as they present considerable difficulties, both of diagnosis and treatment. In the following account of them, I have availed myself largely of the valuable essay upon the subject by Dr. R. W. Smith, of Dublin.[2]

A. *Fractures of the upper end of the humerus* are usually produced by direct violence, as severe blows, or more frequently falls, in which the shoulder comes in direct and violent contact with the ground or some hard substance. Sometimes, however, they appear to have been caused by falls upon the elbow or hand. The point at which the fracture occurs

[1] Med.-Chir. Trans., vol. xxii., p. 100.
[2] Ibid., vol. xli., p. 447.
[3] No. 1097[85].

[1] Traité des Maladies des Os, 1751, tom. i., p. 227.
[2] Op. cit., chap. iv., p. 176.

may be (1) the anatomical neck of the bone; (2) the line of junction of the epiphysis with the shaft, *i. e.*, immediately below the tuberosities; or (3) a little lower down, at that part of the bone called the surgical neck. A fourth form of fracture in this neighborhood is the separation of the greater tuberosity from the remainder of the bone. As the capsular ligament of the scapulo-humeral articulation is attached just below the anatomical neck, the first of these fractures is intracapsular; the others are all extracapsular; an important distinction, both as regards their symptoms and prognosis.

Fig. 178.

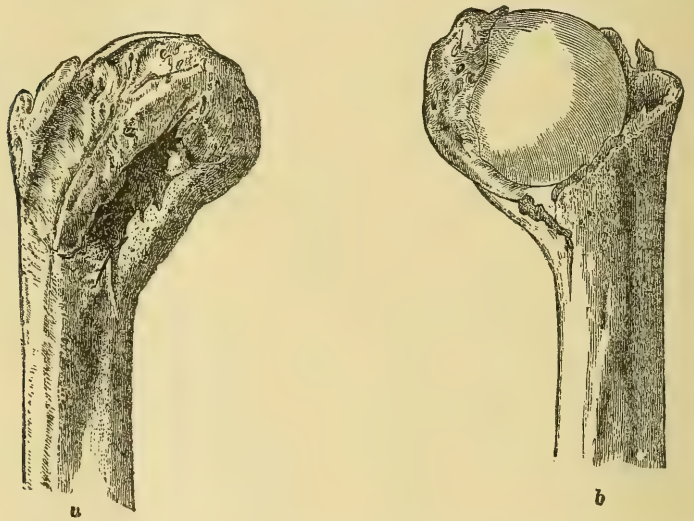


FIG. 178. Fracture through the anatomical neck of the humerus. From a preparation in the Museum of the Royal College of Surgeons; Catalogue, No. 2933. *a* anterior, *b* posterior view. "The shaft is drawn forwards, upwards, and inwards; the outer surface of its upper end is united by bridges of bone to the broken surface of the head and neck, and the anterior fourth of the head rests in a cavity on the top of the shaft." The patient was a woman aged seventy-seven.

1. *Fracture at the anatomical neck of the humerus.*—A glance at the form of this part of the bone will be sufficient to show that fracture here must be a rare accident; yet sufficiently numerous specimens are to be found in museums, and post-mortem examinations are on record to establish the claims of this injury to a place in surgical pathology. Displacement of the separated fragment cannot be caused by the action of muscles, as none are inserted into it; but not unfrequently, from the violence with which the shaft is driven against it, the head, lying loose in the capsule of the joint, slips off the shallow glenoid fossa, is forced through the capsule into the axilla, or sometimes is even turned completely round, so that the cartilaginous surface is in contact with the fractured end of the lower fragment. Cases are recorded in which it has united in this, and other almost equally remarkable positions.[1]

[It would appear likely that in some cases the head of the humerus is "chipped off by the anterior edge of the glenoid cavity," the fracture being produced while dislocation is in process of taking place; and under such circumstances "a continuation of the force might drive the broken extremity of the shaft upon the articular surface of the head (now directed forwards) producing a more or less complete impaction." (Eve, Subcoracoid dislocation of the humerus. Medico.-Chir. Trans., v., 63)].

If the head of the humerus be completely separated, we might expect that it would remain as a foreign body in the joint, and then perish from want of nutrition, and be eliminated by suppurative action, unless previously removed by operation; but Gurlt had been unable to find a single authenticated instance of simple fracture of the anatomical neck where the completely separated head of the humerus had become a sequestrum and had been thrown out.[2] Ligamentous and even osseous union has been met with in some cases; but in these the separation has probably not been entire,

[1] R. W. Smith, op. cit., p. 194; Malgaigne, op. cit., tome i., p. 529; Sir A. Cooper, Treatise on Dislocations and on Fractures of the Joints edited by Bransby Cooper, 1842, p. 417.

[2] Handbuch der Lehre von der Knochen-, brüchen, Th. 2, p. 745.

portions of the capsule attached to the upper fragment having maintained its vitality. The reparative action is, as might be supposed, chiefly accomplished by the lower fragment, which often throws out bony spicula to such an extent as to form a complete cup surrounding the head.[1] It not unfrequently happens that the head of the bone is impacted in the cancellated structure of the thick upper end of the humerus, between the tuberosities. This condition is far more favorable for osseous union than the former, though of course it must occasion some permanent deformity of the joint.

The signs of fracture of the anatomical neck without impaction are not very obvious, unless the head of the bone be much displaced; in fact, pain at the seat of injury, some impairment of motion, and crepitus, with absence of the characteristic signs of other fractures in this neighborhood, are the only evidences to be depended on. In impacted intracapsular fracture, according to R. W. Smith, "the arm is slightly shortened, the acromion process projects more than natural, and the shoulder has lost to a certain extent its rounded form, the upper extremity of the shaft of the humerus is approximated to the acromion, and the entire of the globular head of the bone cannot be felt. In consequence of the fracture of the tuberosity (which often accompanies impaction of the head of the bone), crepitus can be readily detected, when the shoulder is grasped with moderate firmness and the arm rotated."

2. *Fracture at the line of junction of the epiphysis.*—As the large epiphysis at the upper end of the humerus, which includes the head and the two tuberosities, is usually united with the remainder of the bone at the age of twenty, it is only in youth or early manhood that we can expect to meet with this injury. At these periods its occurrence is not unfrequent. The upper fragment remains in the glenoid cavity, the superior end of the lower one is drawn inwards by the action of the muscles passing from the chest to the humerus, forming a marked projection situated beneath the coracoid process; but, owing to the breadth of the bone at this part, it is almost impossible that the two broken surfaces should leave each other so completely as to cause any riding, and consequent diminution in the length of the arm.

The following are the signs presented by this injury: the axis of the humerus is directed upwards, inwards, and forwards; the elbow, however, projects but little from the side; the head of the bone can be distinctly felt in the glenoid cavity, and it remains motionless when the shaft is rotated. The projection above spoken of, formed by the upper end of the diaphysis, does not present the sharp irregular margin of an ordinary fracture; on the contrary, it feels rounded, and its superior surface is smooth and slightly convex. "By pressing this part outwards, and directing the elbow inwards during extension and counter-extension, crepitus can be perceived, and the deformity removed without much difficulty; but the moment the parts are abandoned to the uncontrolled action of the muscles, the deformity recurs" (Smith). The same author observes, that "there is no fracture incidental to the upper end of the humerus in which it is more difficult to maintain the fragments in their proper relative position."

[Professor Moore, of Rochester, N. Y., reported (Trans. Am. Med. Assoc., 1874), three cases of incomplete epiphyseal separations, the upper end of the lower fragment being moved inwards about one-fourth of its breadth and fixed in a natural depression in the lower surface of the head. Replacement was effected by "carrying the arm forward and upward to the perpendicular line. The retention is effected by moderate extension while bringing the arm down to the side, maintaining this slight extension until dressings for the purpose of continuing it are applied." That such epiphyseal separations are always incomplete is doubted by Hamilton and Agnew].

3. *Fracture of the surgical neck of the humerus.*—This is the most common of all the fractures in this region. The part of the bone implicated is that between the tuberosities, and the insertion of the pectoralis major and latissimus dorsi muscles. The line of fracture is generally transverse, but it may be oblique. The amount of displacement of the fragments varies considerably. In characteristic examples the upper fragment is tilted upwards and outwards by the muscles inserted into the great tuberosity, the lower fragment is drawn inwards towards the axilla by those inserted into the bicipital groove, while the various muscles which pass from the scapula to the humerus tend to draw it upwards, an effect which will be greatly facilitated if the line of fracture is oblique. The upper end of the lower fragment has occasionally been observed to project anteriorly, externally, and even posteriorly[1]—differences depending probably upon the direction of the line of fracture, and also upon the direction from which the violence causing the injury proceeded. Impaction of the broken ends frequently occurs, in which case (contrary to what obtains in fracture of the ana-

[1] Sir A. Cooper, op. cit., p. 428; R. W. Smith, op. cit., p. 190.

[1] Malgaigne, op. cit., tome i., p. 516.

tomical neck) the lower fragment usually penetrates into the cancellous structure of the superior.

In impacted fracture there is very little alteration in the form of the limb, and the signs are remarkably obscure, and chiefly of a negative character. The usual signs accompanying non-impacted fracture are as follows. There is no flattening beneath the acromion, the head of the bone remaining in the glenoid cavity, where it can be felt lying motionless when the arm is rotated; the prominence caused by the upper end of the lower fragment can also be readily detected. This is rendered more distinct, and is felt to move with the rest of the bone, when the elbow is pushed up and rotated; the arm should merely be bandaged to the side, the forearm supported in a sling, the swelling and inflammation reduced by the application of cold lotions; and, as R. W. Smith observes, "the prudent surgeon will never omit to announce to the patient, that a certain degree of impairment of the motions of the joint will be a permanent result of the injury."

In the ordinary fracture of the surgical neck, the method usually followed (almost the same as that described by Sir A. Cooper) is, to place a pad in the axilla to act upon the upper end of the shaft, with small straight wooden splints behind and in front, or a single one on the outside of the arm; to bandage the elbow to the side;

Fig. 179.

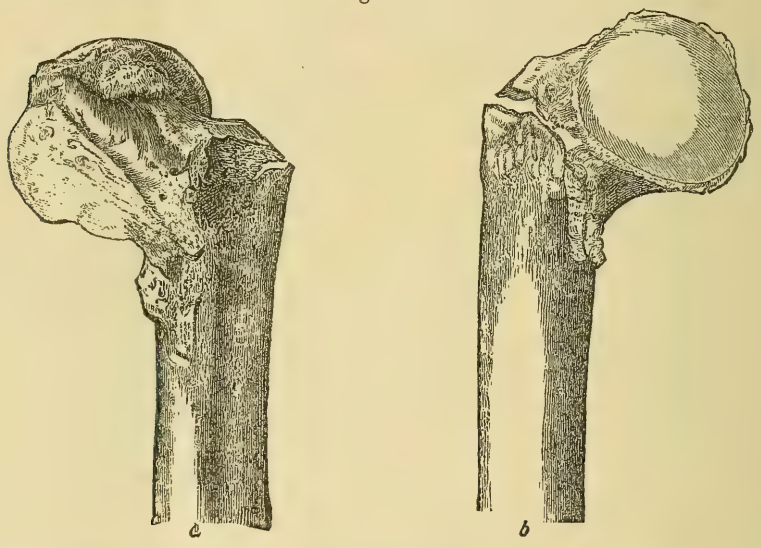


FIG. 179. Fracture through the surgical neck of the humerus. *a* front, *b* back view. The preparation in the Museum of the Royal College of Surgeons, was removed from the body of a woman aged seventy-nine. "There is considerable displacement . . . the upper part of the shaft being drawn forward, and its lower end turned backwards and outwards. Union by ligament took place, and some new bone is formed around the ends of the fractured part." The patient recovered considerable power in the arm; she could make all the usual underhand movements, but could not raise the shoulder or upper arm. Catalogue, No. 2934.

the mobility of the shaft of the humerus is very free, and crepitus distinct, when extension is made. There is usually much pain shooting down the fingers, from the irritation of the axillary plexus of nerves, increased, of course, by all attempts at motion.

Treatment of fractures of the neck of the humerus.—The treatment is the same in principle for all the above fractures: its details will be guided, to a great extent, by the amount and nature of the displacement.

If impaction has occurred, it is very undesirable to disengage the ends of the bone, as this condition greatly facilitates union, especially in the intracapsular variety. The and to support the hand in a sling, letting the elbow hang, so that the weight of the arm may tend to overcome the action of the muscles which raise the lower fragment. A gutta-percha cap, moulded to the shoulder, and extending down the outside of the arm nearly to the elbow, is a convenient substitute for the splints. Another plan, recommended by Erichsen,[1] answers well in some cases: a leather splint, about two feet long by six inches broad, is bent upon itself in the middle, so that one-half of it may be applied lengthwise to the

[1] Science and Art of Surgery, Am. ed., vol. i., p. 438.

chest, and the other half to the inside of the injured arm; the angle formed by the bend, which should be somewhat rounded and well padded, being pressed up into the axilla.

Passive motion should be employed as soon as union is effected, which, according to Sir A. Cooper, is in about one month in youth, but requires from two months to twenty weeks in old age. Malgaigne allows from thirty to thirty-five days as the period at which passive motion should be commenced, in ordinary cases. The same author also gives the important advice, that the elbow, wrist, and finger-joints should be kept in exercise throughout the treatment, as by this means some of the stiffness, which always follows the confinement and want of use of these articulations, will be obviated.

4. *Fracture of the greater tuberosity* is not at all uncommon in connection with dislocation of the head of the humerus forwards, when the detached process is either drawn backwards by the action of the three muscles inserted into it, and lies in the glenoid fossa of the scapula, or is retained in connection with the humerus by unbroken portions of the periosteum or capsular ligament.[1]

This fracture has been said to occur alone, being caused either by direct violence, or by sudden action of the posterior scapular muscles. R. W. Smith has given a detailed account of the symptoms and pathology of this accident, as observed in two cases, in one of which a post-mortem examination was obtained. In both of these, however, there appears to me to have been an actual dislocation of the head of the humerus, beneath the coracoid process, which must be looked upon as the primary abnormal condition, and the fracture of the tuberosity only as a concurrent circumstance; unless, indeed, it could be supposed that the action of the subscapularis muscle, when deprived of its usual antagonists, could be sufficient to displace the humerus to the extent indicated.[2]

B. *Fractures of the shaft of the humerus.* The humerus is broken very much more frequently in some part of its shaft than in either extremity; the seat of the fracture being more often below than above the middle of the bone.

The common causes are either direct violence or falls on the hand or elbow. Many well-authenticated cases are on record in which it has been produced by muscular action alone. These cases have generally occurred in the act of throwing a stone or ball, striking a blow, suddenly seizing some support while falling, or in a practice formerly frequent, of trying the strength of the arm, in which two men rest the elbows on a table, place the palms of the hands in contact, and each endeavors to press his adversary's arm down.

A case of this kind was described, as long ago as 1791, by Debeaumarchef; and Lonsdale reports two as occurring under his own observation at the Middlesex Hospital. Numerous examples of fracture of the humerus from muscular action are collected by Malgaigne;[1] and others have appeared more recently in the journals.[2] In some of these there probably existed a previous condition of the bone which rendered it particularly susceptible to fracture; but in most of them there seems no reason to suspect that it was otherwise than perfectly healthy.

The line of fracture is usually transverse, but it may be oblique. In the latter case it may pass in any direction, though perhaps most often from above, downwards and outwards. Transverse fractures are usually attended with little or no displacement; when oblique, the position of the fractured extremities is determined by the direction of the line of fracture. The principal effect of muscular action is to approximate the extremities of the bone, and thus produce riding of the fragments and shortening of the limb. [When the fracture is approximately transverse and situated in the upper part of the lower third of the humerus, the brachialis anticus on the anterior, and the triceps on the posterior surface serve as splints, and tend to prevent, rather than to produce separation.] The deltoid, however, tends to tilt upwards and outwards that part of the humerus into which it is inserted: hence surgical writers frequently make a distinction between the fractures above, and those below, the insertion of this muscle; in the former, the fractured end of the upper fragment inclines inwards, and that of the lower, outwards; in the latter, the end of the upper fragment projects outwards, and the lower inwards—a distinction, however, of not much practical importance. Shortening of the limb does not generally take place to any great extent, as the actions of the muscles have a counterpoise in the weight of the lower part of the arm.

The signs of fracture of the shaft of the humerus are obvious, and the diagnosis is unattended with difficulty. There is pain, loss of power in the arm, and usually some deformity; and as the two portions can easily be grasped separately, their mobility

[1] See page 871.

[2] Malgaigne does not recognize "fracture of the greater tuberosity" as a distinct injury, and cites Smith's cases as examples of true "intracoracoid" luxation of the humerus. Op. cit., tome ii., p. 518.

[1] Op. cit., tome i., pp. 531 et seq.

[2] See Medical Times and Gazette, 1857, 2d vol., pp. 85 and 254.

is readily ascertained, and crepitus produced. Simple fractures without displacement generally unite favorably; yet, according to the commonly received opinion, there is no bone so subject to ununited fracture, and the formation of false joint, as the humerus. The statistical tables drawn out by Norris show an equal liability in the femur.[1] [In Muhlenberg's table, of 656 cases 219 were of the humerus and 155 of the femur. Of 1005 cases collected by Berenger Féraud, 303 were of the humerus, and 294 of the femur.] Twenty-five to thirty days are usually required to effect consolidation in young subjects, and thirty-five to forty in adults. (Malgaigne.)

Treatment.—In ordinary cases, after the fractured ends are brought into apposition, by extension, if necessary, four small, straight, well-padded wooden splints should be applied, one on each side of the humerus; the elbow bent at a right angle, and allowed to hang down, while the hand is supported in a sling. The splints should be so narrow as not to overlap each other, and must be confined to their place by straps and buckles, or broad strips of adhesive plaster. The starched bandage or gutta-percha will often be found a useful substitute. If the fracture is very oblique, and attended with much displacement from muscular action, although the weight of the arm aids us somewhat, some further permanent extension is frequently required, in order to avoid deformity of the limb. Much may be done by careful management of the splints and pads, arranging them so as to press the projecting parts into place; something also may be accomplished in the way of extension by the splint on the inside of the arm (the top of which is well padded) being made to press into the axilla on the one hand, and against the upper edge of the inner condyle on the other; this plan, however, must be regulated with care, otherwise the pressure of the upper end upon the axillary veins is apt to cause the arm to swell. Unfortunately all the mechanical contrivances which have hitherto been invented for the purpose of effecting extension, are more or less open to objections, and have fallen into disuse almost as soon as they have been made public. [As a general method of treatment the use of the plaster-of-Paris immovable dressing will be found most advantageous, either the roller or the Bavarian splint being employed.]

C. *Fractures of the lower end of the humerus.*—While fractures of the shaft of the humerus are met with in not very dissimilar proportions in both sexes, and at all ages, those of the class now under consideration occur chiefly among young men and boys, with whom also dislocations at the elbow-joint are most frequent.

The fractures of this part of the bone may be divided, as in the upper end, into those that are external to the joint, and those which implicate the synovial membrane. To the first class belong: fracture of the humerus just above the condyles; separation of the lower epiphysis; and fracture of the projecting point of the internal condyle (called by the French the "epitrochlea," by Hamilton "internal epicondyle"). In the second division are: transverse fracture of the lower end of the humerus with a vertical fissure extending through the lower fragment, so that the condyles are separated both from each other and from the shaft; and an oblique fracture separating one or other of the condyles, with a contiguous portion of the articular surface, from the rest of the bone.

1. *Fracture across the shaft of the humerus at its lower end* ("*fracture sus-condylienne*," Malgaigne), immediately above the condyles, where it is expanded laterally, and is very thin in the antero-posterior direction, is not an uncommon accident at any age, although in childhood and youth a separation of the lower articular epiphysis will be more likely to occur under the circumstances which would occasion this injury. The most common cause of this, as well as of all the other fractures in this situation, is a fall upon the elbow while bent. The line of fracture is sometimes transverse, though more often oblique from before upwards; but it may run in the reverse direction, or even slant laterally.

The nature and amount of deformity are determined by the direction of the line of fracture, and also sometimes by the mode in which the injury is inflicted. The powerful action of the muscles passing from the upper arm to the forearm usually causes a great tendency to shortening and riding of the fragments. In most cases the lower one is drawn backwards and upwards by the triceps, producing an appearance similar to that caused by dislocation of both bones of the forearm backwards. The olecranon projects unnaturally, there is a hollow above it, and corresponding to this in front of the arm, a prominence formed by the lower end of the shaft of the humerus. The motions of the elbow and forearm are more or less impaired, though there is not that absolute immobility that is met with in dislocation. As a mode of distinction between this fracture and dislocation of the forearm, Sir A. Cooper gives "the removal of all marks of dislocation on extension, and their return as soon as extension is discontinued," as well as the crepitus detected on rotating the forearm upon the elbow; but as frac-

[1] See FRACTURES, p. 503.

ture of the coronoid process might produce signs similar to these, the following diagnostic characters, dependent upon the fact of the condyles and articular portion of the humerus being displaced with the bones of the forearm, are important: "The projection of the olecranon posteriorly is not more distant from the condyles of the humerus than in the natural condition, if there is fracture, but it is much more so in dislocation; also in fracture the anterior projection is not so broad and rounded, and is *above* the fold of the elbow, while in luxation it is much below it. It may be added that, in measuring the arm from the acromion to the prominence of the internal condyle, a shortening will be found in fracture which does not exist in luxation." (Malgaigne.)

Treatment.—Extension made by grasping the humerus with one hand, and the forearm with the other, will in general suffice to bring the fragments into proper apposition. To retain them so, the elbow should be fixed at a right-angle on a jointed wooden splint, or, what is more convenient, a gutta-percha [or plaster-of-Paris] splint moulded to the parts while they are in good position, and extending along the posterior surface of the upper arm, behind the elbow, and under the forearm and hand, so as to give good support to the latter. In addition to this, a small straight wooden splint should be fixed in front of the arm, its lower extremity resting on a pad placed over the projecting end of the shaft of the humerus, and firmly strapped to the larger splint. This arrangement may of course be varied, according to the inclination of the displacement of the fractured portions of bone. Passive motion should be commenced in about three weeks, otherwise the elbow-joint will become rigid.

A larger or smaller portion of the *inner condyle* (*epitrochlea*) may be broken off without implicating the articular end of the bone. [Many of the cases being doubtless those of separation of the ununited epiphysis.] Attention was first directed to this injury by Granger.[1] It may be occasioned by muscular action, or more commonly by direct falls upon the inner side of the elbow. The detached portion is usually drawn somewhat downwards by the action of the muscles arising from it. Impairment of the motion of the limb, the mobility of the fragment, and the crepitus, will suffice to distinguish the nature of the accident, unless the swelling is very great. A complication sometimes arises from injury to the ulnar nerve. In the treatment, the elbow, as well as the wrist and fingers, should be semiflexed, so as to relax the muscles which arise from the inner condyle. The injured fragments can seldom be retained perfectly in place; but though some deformity may remain, the movements of the elbow are generally but little interfered with. Passive motion should be resorted to early. [See note p. 858.]

Fig. 180.

Fig. 180. Comminuted fracture of the lower end of the humerus, extending into the elbow-joint. From a preparation in the Middlesex Hospital Museum; Catalogue, No. i., 23, d. The patient, a man, aged forty, fell from a considerable height, and sustained this and other serious injuries, which proved fatal.

2. The remaining fractures of the lower end of the humerus are of a more serious character, as they are necessarily attended with more or less inflammation of the joint, and are consequently almost always followed by some permanent impairment in the movements of the elbow. If the great swelling which frequently comes on after these injuries should mask the nature of the fracture, it will be best to keep the arm at rest, laying it on a pillow, if the patient can be kept in bed, or lightly confined by an angular splint, and treated with evaporating lotions, and other antiphlogistic measures, as the case may demand, until, by the subsidence of the inflammatory

[1] Edin. Med. and Surg. Jour., vol. xiv., p. 196.

action and swelling, the exact seat of the injury will become apparent.

The symptoms of the first-named of these injuries resemble those of a fracture across the lower end of the shaft of the humerus. The separation of the condyles from each other may be ascertained by grasping and moving them backwards and forwards, when, unless the swelling and effusion into the joint are very great, crepitus will be obtained.

A single fracture, extending obliquely from either the outer or inner side of the humerus, just above the condylar projection, downwards into the joint, and displacing more or less of the articular surface of the bone with the condyle, is commonly spoken of as *fracture of the outer* or *inner condyle*, as the case may be. Of these, according to Malgaigne, the former is most common; but my experience decidedly leads me to agree with South[1] and others, that the latter is most frequently met with. [Hamilton states that he has seen twenty cases of fracture of the internal condyle and twenty-nine of the external, "this difference in frequency being slight, but a little in favor of the external condyle."]

The amount of displacement depends upon the size of the piece broken off, and the continuity of its ligamentous connections. If these remain tolerably intact, scarcely any deformity ensues. The best diagnostic sign is obtained by grasping the projection of the injured condyle between the finger and the thumb, when it will be found to move separately from the rest of the bone; crepitus will also be usually produced in this way, as well as by rotating the radius, if it be the external, or by flexing and extending the ulna, if it be the internal condyle.

In the *treatment* of the above injuries, the elbow should be bent at a right angle, and fixed by a jointed wooden splint, or the gutta-percha apparatus recommended above for fractures of the lower end of the shaft of the humerus. Sir. A. Cooper advises that passive motion should be commenced at the expiration of three weeks after the accident in the child, and at a month in the adult. This practice has been followed by most English surgeons. Malgaigne begins to move the joint on the twentieth day. The following rules, given by Dr. F. H. Hamilton, deserve consideration: "Within seven days, and perhaps earlier, passive motion must be commenced, and perseveringly employed from day to day, until the cure is accomplished; indeed, in a majority of cases, it is better not to resume the use of splints after this period; for although at this time no bony union has taken place, yet the effusions have somewhat steadied the fragments, and the danger of displacement is lessened, while the prevention of anchylosis demands very early and continued motion."[1] [Dr. Allis, of Philadelphia, has taken strong ground against the rectangular position in the treatment of these fractures of the humerus near to or involving the elbow-joint; and against early resort to passive motion. The result of the ordinary method of dressing is, he claims, to destroy the natural angularity of the upper extremity at the elbow and to substitute therefor an "obtuse angle on the ulnar side of the limb;" and this, no matter whether anterior, posterior or lateral rectangular splints are used, or the fracture treated simply by position. To prevent such deformity he advises that the limb should be dressed in the extended position, and immobility secured by adhesive plaster or "egg paste." Such immobility he would maintain until consolidation of the fracture has taken place, never using "passive motion, under any circumstances, earlier than the fourth week; in the milder and middle grades having never any trouble with functional returns—while in the severest grades of injury there is great injustice done the medical profession, as well as to the patients, by intimating that any course whatever would have insured a prompt return to usefulness."]

A very severe crush, such as might be occasioned by the passage of a heavy body over the joint, may produce even greater complication of fracture than any of the above, but this is uncommon unless there be an external wound also. For the treatment of compound fractures of the elbow-joint, see p. 843.

Fractures of the Bones of the Forearm.

A. *In the vicinity of the elbow-joint.*—1. *Fracture of the olecranon.*—This injury is much more frequently met with in men than in women, and principally during middle life. Before the age of fifteen it is almost unknown. In the table at p. 845, its relative frequency is 3.17 per cent. It is generally caused by a fall upon the back of the elbow when bent, or by a direct blow; but a sudden contraction of the triceps muscle has been said to produce it. The portion that is separated varies in extent, from a mere shell of bone to the whole of the process. The fragment may be retained in its place by its strong ligamentous connections and periosteum, but it is more frequently drawn away from the remainder of the bone by the action of the triceps, to the extent of from half an inch to an inch and a half; the interval being increased when the arm is bent. The power of motion in the arm, especially of extension, is

[1] Translation of Chelius's Surgery, vol. i., p. 557.

[1] Op. cit., p. 262.

very much impaired. If the fragment is separated, the diagnosis is usually made without difficulty. On tracing the subcutaneous border of the ulna backwards, a distinct depression is felt at the elbow, above which the detached olecranon, easily movable from side to side, can be felt. Crepitus cannot be produced unless, on extending the forearm, the fractured surfaces can be brought into contact with one another.

The fragment unites usually by ligament only; but perfect osseous union does occasionally occur, of which we have proof in a case reported by Mr. F. D. Fletcher, of a boy aged sixteen, who fractured both olecranons, and whose death ten months afterwards afforded an opportunity of examining the state of the injured parts. The displacement had not been very great.[1]

Treatment.—The main indication is to keep the triceps relaxed; the next, to endeavor by mechanical means to maintain the detached portion in its normal situation. To effect the former, the arm is to be kept extended. The flexed position of the elbow, used in all other fractures about the joint, is quite inadmissible in fractures of the olecranon. Generally, a straight wooden splint, well padded, is fixed along the front of the arm; but gutta-percha not only has the advantage of accurately adapting itself to all the inequalities in the form of the limb, but also, owing to its possessing a slight degree of elasticity, is more comfortable. It should extend from the upper part of the arm to the wrist, and be fixed by two or three bands of adhesive plaster. [Here, as in all other cases of fracture in which immobilization is desired, plaster-of-Paris is preferred by most surgeons.] To fulfil the second indication, which is only necessary when the displacement is great, a roller should be placed upon the arm, from the fingers upwards, and where it comes to the elbow, it may be made, by a figure-of-eight arrangement, to press the top of the olecranon downwards. Sir A. Cooper recommends that a piece of linen bandage be placed longitudinally on each side of the joint; over these, wetted rollers are to be applied round the arm, one above and another below the elbow; the extremities of the linen are then to be doubled down over the rollers, and tightly tied, so as to cause their approximation. In a month the splint should be removed, and passive motion commenced, but with great caution, as bending the elbow necessarily puts the newly-united part on the stretch.

As this fracture usually extends into the joint, and is in most cases occasioned by direct violence, some inflammation of the synovial membrane will necessarily take place. Too great action should, however, be guarded against, by the usual antiphlogistic treatment; and if it proceeds to such an extent as to threaten anchylosis, the extended condition of the arm should be relaxed, so that the elbow may become fixed in the position most convenient and useful to the patient.

2. *Fracture of the coronoid process of the ulna* is said to occur in connection with dislocation of the radius and ulna backwards, and also to be sometimes met with without that complication.

The cases that have been reported in which it has been observed in the living subject are all more or less unsatisfactory, and have differed considerably in the symptoms which they presented. I have been able to meet with but three or four specimens and recorded post-mortem examinations of this injury; one of the former is in the Museum of Guy's Hospital.[1] Another case is that of a man killed by a fall from the roof of St. George's Hospital, in whom the coronoid processes were found to be fractured, and the two bones of the forearm dislocated backwards on both sides. The specimens are now preserved in the Museum of the hospital.[2] Dr. F. H. Hamilton, after a careful analysis of all the published cases, arrives at the conclusion that this injury is extremely rare.[3]

Should the nature of the accident be recognized, the most appropriate treatment will be to keep the arm at rest in the flexed position, so as to relax the brachialis anticus muscle. In about a month passive motion may be gently commenced.

3. *Fracture of the neck of the radius.*—Surgical authors differ considerably in their estimate of the comparative frequency of this injury, the result chiefly of the difficulty of making an absolutely certain diagnosis during life. South says, that it "is not an uncommon accident, and very liable to be confused with dislocation of the bone forwards on the outer condyle of the upper arm. It is accompanied with much distortion and swelling, and, being naturally deeply imbedded in the muscles, is difficult to make out satisfactorily. The head of the bone must be grasped with the thumb and finger of one hand, whilst the other draws the lower end of the bone from it, by pulling at the hand alone; and then, upon rotation, if there be fracture, the crepitation will be felt."[4] The post-mortem proof of such a fracture is, however, almost entirely wanting. As the head of the bone is an epiphysis, and does not unite

[1] Medical Times and Gazette, 1851, vol. ii., p. 173.

[1] No. 1119[25].
[2] Series i., Nos. 111, 112.
[3] Op. cit., p. 342 [6th ed.]
[4] Translation of Chelius, vol. i., p. 559.

until the age of puberty, we should expect to find its separation from the shaft more common before that age than at any other period of life.

Malgaigne reports two cases in which a post-mortem examination showed a fracture extending through the head of the radius, both of them in combination with other severe injuries to the neighborhood of the joint. In the two specimens of fracture of the coronoid process referred to above in the Museum of St. George's Hospital, the head of the radius was also split longitudinally.

B. *Fractures of the middle of the fore-arm.*—1. *Fracture of both radius and ulna.*—The two bones are broken together at this situation more frequently than is either the ulna or radius alone. Direct violence is the most common cause; a blow, the passage of a wheel over the arm, or a fall in which some hard substance is struck. In the numerous cases of fracture of the forearm occasioned by falls upon the hand, it is almost always the radius, which receives the shock directly from the carpus, that is broken, the ulna not often participating in the injury. Malgaigne relates a case of fracture of both bones of the forearm from muscular action, occurring while digging; the only one on record, as far as I am aware, from this cause.

The most frequent seat of fracture is about the middle or lower third; the upper part being, from its situation and its more complete muscular covering, less exposed to injury than the more distant. The line of fracture is usually transverse, or nearly so; it is often at the same level in the two bones, or if not, generally higher in the radius than in the ulna. The nature and amount of displacement of the fragments vary much; it may be almost or quite absent; but usually both bones will be bent at an obtuse angle, either forwards, backwards, or on one side; or one only may be bent, its broken ends falling in towards the companion bone. Oblique fractures are generally accompanied by a riding of the fragments, and shortening, more or less marked, of the limb. In transverse fractures, it is not common for the faces of the broken extremities to separate completely, so as to allow them to overlap each other; but this happens sometimes, and the overlapping may be in different directions in the two bones, the lower fragment of the radius being in front of the upper, and that of the ulna behind, or *vice versa*. Incomplete, or "greenstick," fractures of the bones of the forearm are very frequently met with in children.

The diagnosis is usually simple; the pain and loss of power, the unnatural bend in the arm, the soparate mobility of the upper and lower parts, and the crepitus, are signs which indicate the nature of the accident. These fractures are often troublesome to manage, the fragments having a great tendency to become displaced, and so permanent malposition of the bones, causing loss of rotation of the fore-arm, is not an infrequent result. The power of rotation is sometimes lost, even in cases where the bones have united in tolerably good position, from deposits of new osseous matter taking place between them, and soldering them together, or, as Lonsdale[1] suggests, from the upper and lower fragment of the radius being in a different position as regards supination at the period of union; the former being completely supinated by the action of the muscles attached to it, while the latter, in the usual method of treatment, is kept in a semi-prone position; hence, after union, complete supination of the hand becomes impossible. I have found a proof of the truth of this conjecture in an examination of numerous specimens of united fractures of the radius, in the great number of which the lower fragment was much less supinated than the upper.[2] Want of union is another and more distressing result, which occasionally follows this fracture. To guard against such untoward events, the splints and bandages have often to be applied tightly, in consequence of which a still greater evil, gangrene of the extremity, has occurred more frequently in this than in any other injury of a similar nature, especially in children.

Treatment.—If there is much displacement and shortening, reduction must be effected by extension applied at the wrist, while counter-extension is made at the elbow, the forearm and fingers being semi-flexed to relax the muscles; at the same time the broken ends may be brought into proper apposition by manipulation. The position in which the forearm is now to be placed has long been a subject of controversy among surgeons. Although the state midway between pronation and supination, which is most comfortable to the patient, is generally adopted, yet when the fragments are much displaced, and have a tendency to fall together and diminish the inter-osseous space, complete supination, recommended by Lonsdale, for the reasons above mentioned, and more recently advocated by Malgaigne, is better adapted to produce a satisfactory result.

The objectionable plan of tightly bandaging the limb before putting on the splints, is now justly discarded by most surgeons, on the ground that it prevents the fulfilment of the important indication of keeping the

[1] Op. cit., p. 125, and London Medical Gazette, vol. ix., 1832.

[2] See especially preps. Nos. 2950 and 2951 in Mus. Roy. Coll. Surg.

two bones apart. On the contrary, a graduated compress is generally placed lengthwise behind and in front, between the radius and ulna, at the seat of injury, so as to press into the interosseous spaces; over these, straight wooden splints, extending from the elbow to a little beyond the wrist, are fixed, and the forearm is suspended in a sling. These compresses have been objected to, as likely to interfere with the circulation of the limb, and, if the splints are properly padded, may generally be dispensed with. [Much the same may be said of these interosseous splints as of axillary pads; if useful they are intolerable; if tolerable they are useless.] It is important that the splints should be fully as wide, or somewhat wider, than the limb, so that the bandages which retain them in place exercise no lateral pressure upon the bones.

2. *Fracture of the shaft of the ulna* is almost always caused by direct violence, either in striking against some hard body, as the corner of a door-step in falling, or when the forearm is elevated to ward a blow from the head, in which position the ulnar side is turned forwards. The middle and lower portions are most commonly the seat of fracture; the superior strength and thickness of the upper, and its less exposed position, rendering it little liable to injury. Displacement, when it occurs, affects the lower fragment only, the other being retained in its situation by the articulation at the elbow; it may be in any direction, determined by that from which the force acting on it proceeds. If there is no displacement, the appearances of bruising and the swelling and pain will mark the point of injury. Mobility of the lower fragment and crepitus may generally be obtained by holding the upper part firmly, and pressing the lower towards the radius. The subcutaneous position of the greater part of the bone adds greatly to the facility of diagnosis. The radius, acting as a kind of splint, prevents shortening, and assists in keeping the parts in apposition; so that the treatment of this fracture is much less difficult than where both bones are broken. Care should be particularly taken that the broken ends do not incline towards the radius, so as afterwards to impede the rotation of the forearm. If there is much tendency to this, pads should be placed between the bones, and the supine position adopted; in other cases, that midway between supination and pronation will be the best. The splints should be straight, one anterior and one posterior; or the starched bandage or gutta-percha may be used. The forearm and hand should be supported in a sling.

3. *Fracture of the shaft of the radius.*—Though the radius is broken more frequently than any other bone of the body, this preponderance is chiefly due to the great number of fractures of its lower end, the middle part being probably not more subject to this injury than the same portion of the ulna. It is occasionally, but very rarely, broken immediately below the insertion of the tendon of the biceps into the tuberosity; an accident which has been, though improperly, described as "fracture of the *neck* of the radius."[1]

Direct violence is the most common cause of fracture of the shaft of the radius, although it may be occasioned by a fall upon the hand. The diagnosis is usually unattended with difficulty, the principal signs being, loss of power of rotation, mobility, and crepitus elicited by pressing the fragments in different directions with the fingers, or on fixing the upper one, and rotating the hand.

The broken ends have a tendency to fall inwards towards the ulna, and so to diminish the interosseous space. This must be guarded against by pads, as directed when speaking of fracture of both bones; the hand should also be supinated [in all cases, certainly, in which the fracture is located between the insertions of the biceps and the pronator radii teres, the forearm should be kept in a state of supination]; and the general treatment recommended in the next section for fractures of the lower end may be adopted.

C. *Fractures of the bones of the forearm in the vicinity of the wrist-joint.*—1. *Fracture of the inferior extremity of the radius.*—Excepting perhaps the middle of the clavicle, there is no single point of the skeleton so frequently the subject of fracture as the lower end of the radius; the reason being, that in falling down the hands are generally thrown forwards, and the whole weight of the body received upon the palmar aspect of the carpus, from which it is directly transmitted to the broad articular surface of the radius; this bone, placed thus between the weight and momentum of the body in falling on the one hand, and the resistance of the ground on the other, gives way at its weakest point, viz., where it commences to expand into the broad articular extremity composed of cancellated tissue, covered with a compact layer much thinner than that of the shaft. [While perhaps in a limited number of cases the fracture may be thus produced, in the large proportion, probably, it is due to a "cross-breaking strain" in consequence of over-extension of the hand, comminution of the lower fragment, when it occurs, being the result of secondary splitting, either by the

[1] See two cases by Mr. J. Moore, London Medical Gazette, vol. xxxvi., 1845, p. 1079.

lower end of the upper fragment or the wedge-like junction of the scaphoid and semilunar bones.] The cause, then, of this injury is almost always indirect violence: it may, however, be occasioned by a direct blow, or a wheel passing over the arm; but in such accidents both bones usually suffer. Although met with frequently in both sexes, and at all periods of life, it is a remarkable circumstance, that while up to the age of thirty it is more prevalent among men, yet after middle life the reverse takes place, and as age advances, this disproportion between the sexes continues to increase; so that among old women, fracture of the lower end of the radius is more frequent than all other fractures and dislocations of the upper extremity taken together.

The pathology of this fracture has been the subject of many special memoirs, and even of much controversy. The earliest accurate description which appeared of it in our language is by Colles of Dublin;[1] hence it is frequently designated by surgical writers as "Colles' fracture." It has more recently been the subject of an elaborate memoir by R. W. Smith[2] of the same city; and on the Continent it has attracted the attention of Pouteau,[3] Desault,[4] Dupuytren,[5] Goyrand,[6] Diday,[7] Voillemier,[8] Malgaigne,[9] and others. [Gordon, of Belfast, published in 1875 a monograph on these fractures, and of late years in this country they have been investigated and reported upon by Moore, Cruse, Packard, Pilcher, and others.]

The line of the fracture is almost always transverse, occasionally it crosses obliquely from side to side; it is usually situated from half an inch to one inch above the articular surface of the bone. [Frequently it is yet lower down, but a short distance above the articular surface. In many cases of this sort, there being no displacement, the injury may readily be mistaken for a sprain of the wrist. If seen early, the "line of limited tenderness" may very generally be easily determined, and thus the diagnosis of fracture established.] In some instances there is scarcely any displacement, but most commonly the lower fragment assumes a peculiar position with respect to the other, which gives a very marked and characteristic appearance to the limb. In the great majority of cases, this displacement is backwards and somewhat upwards; so that in bones in which unreduced fractures of this kind have consolidated, the posterior surface is found to be considerably shortened, while the anterior retains its normal length. The carpal articular surface also, besides occupying a position more posterior than normal, as regards the shaft, has an inclination backwards, instead of forwards, as in the usual state. So that in fact the inferior fragment has undergone a sort of rotation on its transverse axis, a "mouvement de bascule," as the French term it. This change of position is, however, modified by the strong ligaments of the lower radio-ulnar articulation (which do not usually give way) confining the inner side of the fragment more in place than the outer, so that the displacement is more extensive on the side of the styloid process, and the outer border of the bone is shortened to a greater degree than the other; hence it is that the whole hand, which follows the movements of this fragment, is inclined towards the radial side. It is difficult to conceive that this displacement can be effected in any other way than by a penetration of the posterior surface of the superior fragment into the soft cancellous structure of the inferior; an explanation suggested by Voillemier, and adopted with slight modifications by Malgaigne, Nélaton, and Erichsen, but opposed by R. W. Smith, whose opinion is, that, as a rule, no such penetration takes place, "the distortion being the result of the combined action of the supinator longus, the extensors of the thumb, and the radial extensors of the carpus." After a full consideration of the elaborate arguments which have been brought forward on either side to determine this point, it appears to me that the evidence from the examination of specimens of bones in which union has taken place, as well as that derived from the symptoms during life, shows that impaction occurs in a large number of cases, although it cannot be denied that muscular action frequently aids in maintaining the peculiar deformity.[1] [According to Pilcher, the deformity is largely due to the existing immobility of the ulna, consequent upon the stretched condition of "a strong oblique fasciculus of the anterior ligament, extending from the cuneiform bone to the anterior border of the styloid process of the ulna." At the same

[1] Edin. Med. and Surg. Journal, April, 1814.
[2] Treatise on Fractures in the Vicinity of Joints, 1847, p. 129.
[3] Œuvres posthumes, 1783, tome ii., p. 251.
[4] Œuvres chirurgicales, 1813, tome i., p. 155.
[5] Leçons orales, 1834, tome iv., p. 161.
[6] Gazette médicale, 1832, p. 664, and Journal hebdomadaire, fév., 1836.
[7] Archiv. gén. de Médecine, 1837, 3me série, tom i., p. 141.
[8] Ibid., 1842, tome xiii., p. 261.
[9] Op. cit., tome i., p. 603; Gazette médicale, 1832, p. 730.

[1] Dr. Smith says: "In the descriptive Catalogue of the Pathological Museum of St. Bartholomew's Hospital, published in 1846, the same error" (that of attributing the deformity to impaction), "as it appears to me, has been committed. See No. 78, p. 133, and No. 94, p. 136." An inspection of the specimens referred to, has left no doubt on my mind that the description in the Catalogue is perfectly correct.

time with the fixation of the ulna the radial fragments are held in displacement by untorn periosteum on the dorsal surface stripped up from the lower end of the upper fragment. Moore (of Rochester, N. Y.), maintains that in more than half of the cases of this fracture, the deformity is due to a dislocation of the ulna, the styloid process of which is caught under the posterior annular ligament, or driven through its fibres and hooked upon it. As necessary for the production of this dislocation, the tendon of the extensor carpi ulnaris must be displaced from its groove, and generally the internal lateral ligament ruptured and the triangular fibro-cartilage detached. Surgeons, generally, are disposed to consider such "luxation of the ulna as a mere symptom, and not a very constant one."] The question can only be finally decided by a greater number of careful dissections of recent cases, for which opportunities very rarely occur. [The question is still undecided. With perhaps only a single reported exception, experimentally produced fractures have not shown impaction; but such might readily enough occur if the force continuing to act after the primary displacement had taken place was not sufficient to split the lower fragment "into several pieces."] Sometimes the inferior fragment is split into several pieces, apparently from the force with which the lower end of the shaft has penetrated it.

The symptoms of this injury are so pronounced, that it may almost always be recognized at first sight. The patient is unable to perform the motions of supination and pronation, and complains of much pain, especially about the internal lateral ligament of the wrist, which is put upon the stretch. The hand being articulated to the displaced fragment of the radius, is carried with it backwards and towards the radial side; the styloid process of the ulna is thus rendered extremely prominent. The lower end of the radius forms a marked projection on the dorsum of the wrist, and there is a corresponding depression in front. Often in the first instance this portion is not movable upon the shaft, and there is no crepitus; but after disengaging the impacted ends by powerful extension, both these distinctive signs are usually obtained. If there is much swelling from inflammatory effusion, the distinctive characters will be more or less masked; but now that the nature of the injury is so well understood, it will be next to impossible to mistake it, as was formerly frequently done, for dislocation of the carpus backwards, which, by the way, is an extremely rare accident.

Fig. 181.

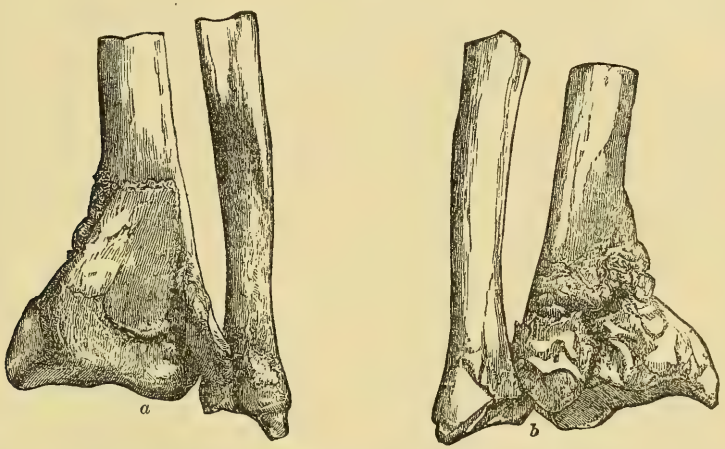


FIG. 181. Comminuted fracture of the distal end of the radius. *a*, anterior view; *b*, posterior. From a preparation in the Museum of the Royal College of Surgeons.

In young subjects, fractures of the lower end of the radius are easily reduced, unite readily, and leave the use of the limb perfectly unimpaired; but in old persons, who, as before stated, are especially liable to this injury, the result is often most unsatisfactory, even after the greatest care has been used during the treatment. It is frequently months before the hand is free from pain, and regains its proper motions, and too often an unsightly, crooked, and permanently stiff wrist remains, to the great inconvenience of the patient, and annoyance of the surgeon.

Treatment.—If the fracture is impacted, extension, while the hand is supinated and adducted as much as possible, is generally

required to unlock the ends of the bones. After this is accomplished, there is still a great tendency to displacement from muscular action, which must be overcome as far as possible by mechanical means. Many surgeons use what is called the "pistol-shaped splint," well padded and fixed along the back of the forearm and hand, so as to keep the latter firmly drawn to the ulnar side, by which means some amount of extension is made upon the lower end of the radius. Another splint, shorter and straight, is adapted to the front of the forearm, its lower end resting on a pad which presses on the projecting inferior extremity of the shaft of the radius. According to Dr. F. H. Hamilton, most American surgeons apply the curved splint to the palmar surface, and the shorter straight splint to the dorsal side of the forearm. They also flex the fingers over a hand-block, or pad, attached to the former. A single straight splint along the back or front of the forearm and hand is used by some surgeons; while others prefer two straight splints, placed one on each side, with pads so contrived as to press the lower fragment of the radius into place, while the hand is left free, and, being unsustained by the sling which supports the forearm, hangs down (to the ulnar side) by its own weight. The advantage gained by this method is, that much of the stiffness of the wrist and fingers, which follows their close confinement in the ordinary method, may be avoided. With very old people, this rigidity often gives so much trouble afterwards, that Velpeau considers it best in such cases to dispense with splints altogether, and merely place the arm upon a pillow.

[Some of the more recent writers, as Moore and Pilcher, have denied the necessity, in ordinary cases, of using splints. The former declares that "the first step in the treatment consists in the restoration of the luxation, when the treatment of the fracture becomes entirely subsidiary. . . . It is a luxation and not fracture that we deal with." Pilcher believes that after reduction has been effected ("by simply binding the hand and wrist backwards, making slight extension in the line of the forearm, and making moderate pressure upon the dorsum of the lower fragment"), the parts will remain in apposition, held by the untorn periosteum, the tendons, etc.; all the dressing required being a simple band around the wrist and a sling. Very full testimony to the safety of thus discarding all retentive apparatus, and to the satisfactory results following, will be required before surgeons in general will feel warranted in abandoning altogether old-time methods of treatment with splints and bandages.]

Many arguments for and against the adducted position of the hand, in the treatment of fractures of the lower end of the radius, have been brought forward. The just view of the subject is probably intermediate between that of its extreme advocates and of those who altogether deny its utility. It is, I think, more advantageous in fractures three or four inches above the articulation than in the cases now under consideration; but in practice I have found little difference in the results of the treatment by the straight or pistol-shaped splint. Much more depends upon the care and accuracy with which the minor details are carried out. The splints should be removed between the third and fourth weeks, and the fingers exercised as much as possible, to overcome their stiffness. There often remains a swelling on the front of the wrist, caused by an indurated condition of the sheaths of the tendons; this must be treated by friction with stimulating liniments, or the application of tincture of iodine

[According to Gordon, as the fracture is produced by overextension, and the deformity is relieved by flexion, it is in the latter position that the hand should be maintained during treatment, adduction producing "displacement outwards and upwards of the lower fragment,—the most marked deformity of the accident." Upon such displacement, he insists, depends the inflammation of the ligaments and sheaths of the tendon; and by the correction of the displacement, and consequent prevention of such inflammation, the "distressing sequelæ may be almost entirely prevented." Levis's well-known tin splint acts on the same principle.]

It occasionally, though very rarely, happens that the lower fragment of the radius is displaced *forwards*. The cause of this injury is said to be a fall upon the back of the hand.[1]

In subjects under the age of twenty, separation of the inferior epiphysis of the radius commonly takes the place of fracture of this part. The symptoms and treatment in both cases are very nearly identical.

2. *Both radius and ulna* may be broken close to their lower ends; an injury presenting at first sight much more the appearance of dislocation of the carpus backwards than does fracture of the radius alone, as there is now no lateral displacement of the hand, and consequent prominence of the styloid process of the ulna. Careful attention to the exact seat of the injury will enable the surgeon to form a correct diagnosis. (See p. 881.)

3. Lastly, *the lower end or styloid process of the ulna* alone may be the seat of a fracture, caused usually by violence applied directly.

[1] R. W. Smith, op. cit., p. 162.

Fractures of the Bones of the Hand.

1. *Fracture of the carpal bones.*—The form and mode of articulation of the bones of the carpus render them very little liable to fracture, except where there has been great violence, as from machinery, or gunshot, in which cases the soft parts are also extensively injured. (See page 843.) Simple fractures do, however, occasionally occur, from the passage of heavy weights, as

Fig. 182.

FIG. 182. A vertical fracture crosses the junction of the middle and inner third of the scaphoid bone. The lower end of the radius is also fractured; the fracture extends obliquely from a quarter of an inch above the lower border, on the anterior aspect of the bone, to the line of union of the posterior with the articular surface. The drawing represents a preparation in the Middlesex Hospital Museum, Catalogue, No. i., 23, c., taken from the same patient as Fig. 180 (comminuted fracture of elbow-joint). The same collection contains a second similar preparation.

cart-wheels, over the hand, or blows and falls on the wrist. Owing to the fragments being retained in their place by their numerous ligamentous connections with the surrounding bones, there are few symptoms beyond those that might be ascribed to a severe bruise, and it is therefore probable that a fracture of one of these bones may often pass undetected.

As post-mortem evidence of simple fracture of any of the carpal bones is not common, the following case may be worth recording. A man, aged forty, was admitted into the Middlesex Hospital, Jan. 3, 1861, having received in a fall several severe injuries, from the effects of which he died. The right wrist-joint had evidently suffered, though there was no external wound or deformity. Acute inflammation, and ultimately suppuration within the joint, supervened. After death, it was found that a piece about one inch in length was split off from the posterior surface of the lower end of the radius, and a fissure extended almost, but not entirely, across the middle of the scaphoid bone.

The *treatment* consists in keeping the wrist at rest, lightly bound to a splint, and in the use of cold lotions, or other antiphlogistic measures, if the inflammatory symptoms are severe.

2. *Fracture of the metacarpal bones.*—These bones are much more exposed to injury than the last-named. The usual cause of fracture in them is direct violence, but we not unfrequently find it occasioned by striking a blow with, or falling upon, the closed fist. It is met with far more frequently in men than in women, and chiefly between the ages of fifteen and forty-five.

The statements that have hitherto been made as to the comparative liability of the different bones of the series to fracture are very unsatisfactory, owing to the insufficient number of observations upon which they are founded. Of the 113 cases which I have collected from the records of the Middlesex Hospital, in 71 the particular bone is mentioned. Of these, four are double fracture (two of the second and third, and two of the third and fourth), and in one the third, fourth, and fifth bones were broken; making in all 78 fractures. The number belonging to each bone is—

1st	27
2d	16
3d	9
4th	12
5th	14
Total	78

Probably an undue prominence is here given to the first, as, on account of its distinctive characters, it is more likely than any of the others to be particularized in describing the nature of the accident. Allowing for this probable source of error, we may still place it foremost in liability of fracture, as might be supposed from its position and extent of motion; the others seem to follow in order, as their situation exposes them to injury, the third or middle bone being last.

The fracture is usually in the middle or distal third of the bone; it is transverse or oblique, often attended with very little displacement, in which case the mobility of the fragments and the crepitus are the

chief signs of the injury. Often, however, there is a displacement of the distal fragment, the head sinking down towards the palm, and the upper end forming with the extremity of the proximal fragment an angular projection on the dorsum of the hand. Sir A. Cooper[1] describes the fracture of the *head*, or more properly of the *neck*, of these bones; in young subjects this is probably a separation of the epiphysis.

The *treatment* of this injury recommended by the eminent surgeon just named, consists in causing the hand to grasp a large ball, and then binding a roller round the whole. I have generally modified this method by using a common rib-roller instead of the ball, and fixing the hand over it by means of adhesive plaster. Where there is much displacement, in order to obtain greater accuracy of adjustment, the plan recommended by Malgaigne is to be preferred. A thick compress is to be placed under the head of the bone so as to raise it, and another over the projection of the dorsal surface; these are kept in place by two broad splints placed across the hand, one above and one below, their ends being firmly drawn together by strips of plaster. The fingers should be left free, so as to avoid too great an amount of stiffness. If the metacarpal bone of the thumb is broken, it must be treated in the same manner as one of the phalanges, which it resembles so closely in its characters.

3. *Fractures of the phalanges.*—From their very exposed situation, these small bones are often broken, usually with wound or severe bruising, amounting frequently to complete comminution of the whole member. Simple fracture of the phalanges is, however, by no means uncommon, and is generally caused by direct and occasionally by indirect force. The first phalanx, being largest and most fixed in position, seems to suffer most; but we have not yet sufficiently reliable data to determine even approximately the relative frequency of injury to the different bones of this series. The fracture usually occurs about the middle of the bone; and although there is rarely much displacement, the diagnosis is generally established without difficulty from the crepitus and mobility of the fragments.

The *treatment* usually recommended is, to fasten a narrow straight wooden splint beneath the finger, with a small pad opposite the middle of the broken phalanx, to fill up the concavity which naturally exists between the joints. The splint may be more conveniently fixed to the dorsal surface, especially when it is one of the phalanges of the thumb that is broken. A more comfortable support is given by a splint of gutta-percha or pasteboard, moulded to the shape of the finger, which may then be allowed to be slightly flexed at each of the joints. It may be released from its confinement, and passive motion may be commenced, at about the end of the third week.

[1] Op. cit., p. 506.

Dislocations of the Bones of the Upper Extremity.

Dislocations of the Clavicle.

The articulation between the sternum and clavicle may properly be regarded as the first point at which a luxation of any of the bones of the upper extremity can take place. As fracture of the clavicle is such a common accident, it has been remarked with surprise by authors, that, considering the extreme smallness and shallowness of the sternal articular surface, dislocation does not oftener occur at this point; and explanations are sought for in the strength of the ligaments, etc. The circumstance is more readily accounted for by the fact, that the clavicle is so confined by surrounding structures as very much to limit the amount of movement at the joint, and it is consequently impossible either that the articulating surfaces can undergo much change in their relation to each other, or that any of the ligaments can be put greatly on the stretch. *Cæteris paribus*, the greater the extent of motion in a bone, the greater the liability to dislocation. Again, the causes which produce dislocation of the clavicle are different from, and not so frequently in operation as, those which usually occasion a fracture. Its relative frequency, according to the table at p. 845, is 3.10 per cent.

The cartilage of the first rib prevents displacement of the head of the clavicle downwards, but it may occur in any other direction. Following the order of frequency in which they are met with, we may describe:

1. Dislocation forwards. 2. Dislocation backwards. 3. Dislocation upwards.

1. *Forwards.*—This may be complete or incomplete: in the former case, the head of the bone, besides projecting forwards, is depressed below its natural level; in the latter, it is usually slightly raised. The ordinary cause of this dislocation is some violence which pushes the outer end of the clavicle backwards, as a fall or blow on the front of the shoulder. In children, it has been produced by simply pulling the arm.[1] It has been observed at most ages, from birth[2]

[1] Melier, Archiv. gén. de Médecine, tome xix., p. 53.

[2] Fergusson, Practical Surgery, 4th edit., 1857, p. 249.

to eighty-six,[1] more frequently in males than females. The prominent head of the clavicle seen and felt in its abnormal situation, covered only by the integument, leaves no doubt as to the nature of the injury, except in partial dislocations, where there is much swelling, or in very fat subjects.

Treatment.—The bone is usually reduced without difficulty by drawing the shoulder outwards and backwards, the surgeon's knee being placed between the scapulæ of the patient; while at the same time, if necessary, an assistant presses the head of the bone back into its place. The great disposition that it has to slip out again has led to the invention of many methods intended to retain it in place; but even after the greatest care, more or less deformity often remains. Fortunately the utility of the limb is not materially impaired, even if the bone remains unreduced. The two objects to be aimed at are: (1) to keep the shoulder fixed, and thrown upwards, outwards, and backwards; and (2) to exert pressure upon the head of the clavicle.

A pad in the axilla, a figure-of-eight bandage to the shoulders, with a sling to support the elbow, or, in fact, any of the apparatus used in fractured clavicle, will fulfil the former indication; while for the latter a common hernia-truss may be applied, the pad being placed on the projecting bone, and the spring passing under the axilla of the sound side, as recommended by Nélaton. [Here again plaster of Paris may be used to great advantage.] The pressure requires to be kept up from six weeks to two months, though at the end of the former period passive motion of the arm and shoulder should be commenced, in order to overcome the stiffness of the joints that so long a confinement must necessarily occasion. Velpeau, upon the supposition that the displacement is chiefly due to the action of muscles, proposes to relax these by carrying the elbow inwards and forwards to the lower part of the sternum, so that the hand may rest upon the opposite shoulder; the outer end of the clavicle will then be inclined upwards and forwards, and pressed inwards.[2]

2. *Backwards.*—This form of dislocation has been produced by a violent fall, driving the shoulder inwards and forwards,[3] by the shoulders being pressed together between a carriage-wheel and a wall, or by a force applied directly, so as to push the inner end of the clavicle backwards, as a kick from a horse. The head of the bone usually lies behind the upper part of the sternum, rather below its normal level. In extreme cases, symptoms dependent upon pressure upon the trachea and œsophagus are produced, as in that related by Sir A. Cooper, in which Mr. Davie of Bungay had to saw off the sternal end of the bone to prevent death from this cause: this, however, was not an example of traumatic dislocation, but was produced gradually by a progressively increasing curvature of the spine.

A characteristic case occurred in the practice of my colleague, Mr. De Morgan, at the Middlesex Hospital, in 1852, which I shall relate briefly, as illustrating the usual symptoms and treatment of this accident.[1] A girl, ten years of age, was knocked down by a carriage, and appears to have been trodden on by one of the horses. On admission, she suffered much from dyspnœa, the head was inclined forwards, and could not be raised without extreme pain. There were marks of bruising over the right shoulder and clavicle. Where the head of the bone should be, there was a depression into which the finger might be thrust, and the articular surface of the sternum could be distinctly felt, while the head of the clavicle was evidently behind it. The distance from the middle line to the acromion was shortened by a quarter of an inch. "On placing the knee against her spine, and gently drawing the two shoulders backwards, the bone was easily restored to its proper place, causing obvious relief to the dyspnœa, but immediately on leaving hold of the shoulders, the bone fell back, and the dyspnœa returned. A splint was then placed across the shoulders, with a pad between it and the spine, the shoulders being drawn to the splint by a bandage; by these means the bone was kept firmly in its place, pillows being so arranged along the patient's back that the splint should not feel uncomfortable. On the apparatus being fixed, she could lean her head backwards, and stated that her pain was much relieved." The splint was kept on for a fortnight; the bone being then quite steady in its place, she was allowed to remain in bed without any bandage. The articulation became in four weeks quite as firm as that on the other side, and the arm could be moved without causing any pain.

South relates a case of compound dislocation of the sternal end of the clavicle backwards, caused by a blow with the sharp end of a pickaxe.[2]

3. *Upwards.*—This accident has only recently acquired an established place in surgical pathology. Malgaigne has collected five examples, and Dr. F. H. Hamilton has added another, which happened in America. [This author in his last edition (1880) refers to *ten* cases as all that he has been able to find report of.] They seem all to have been occasioned by a violent force which carried the shoulder downwards and inwards. The symptoms are

[1] Brasdor, Mém. de l'Acad. de. Chirurg., tome v., p. 588.

[2] Journal hebdom. de Méd., May 30, 1835.

[3] See a case, caused by a fall while wrestling, by Mr. W. Brown of Callington, Medical Gazette, Aug. 1, 1845.

[1] Reported by Mr. S. W. Sibley, Medical Times and Gazette, 1852, vol. i., p. 415.

[2] South's Chelius, vol. i., p. 778. See also, on this subject, Baraduc, Mémoires sur les Luxations de la Clavicule, Paris, 1842.

very marked, the head of the bone being felt above the upper border of the sternum, lying between the sterno-mastoid and the sterno-hyoid muscles. There is probably complete rupture of all the ligaments of the joint, as well as of the costo-clavicular ligament.

Reduction is easily effected by drawing the shoulder outwards and upwards, while the dislocated head is pressed down; but to retain it in this position is difficult, if not impossible. Malgaigne found the functions of the clavicle perfectly restored six months after the accident, although the sternal end was nearly a quarter of an inch above, and as much to the inner side, of its normal situation. In the case mentioned by Dr. Hamilton, the displacement was still greater; but the patient stated "that he felt no inconvenience or abatement of strength in the arm, except when he attempted to lift weights above his head."[1]

Dislocations of the Scapula.

These injuries are usually described as "*dislocations of the acromial end of the clavicle,*" but it seems preferable, for the sake of uniformity in our nomenclature, which has now discarded such terms as "dislocation of the radius and ulna upon the carpus," "dislocation of the tibia at the ankle," etc., to consider it as a dislocation of the acromion process of the scapula from the clavicle, the latter being the more fixed point and nearest to the trunk. This designation has already been adopted by Skey[2] and Maclise.[3] Luxation at this joint is more frequent than at the sterno-clavicular articulation.

In the great majority of cases, the acromion is forced *beneath* the outer end of the clavicle; occasionally the reverse happens, viz., the acromion is situated *above* the clavicle; and a third form has lately been described, in which the displacement is carried so far that the coracoid process, as well as the acromion, are placed above the clavicle.

The cause of this injury is nearly always direct violence applied to the scapula, as in a fall in which the back or outer part of the shoulder comes in contact with the ground or some hard body, or a blow or kick upon the same part. The symptoms of the first and most usual variety are tolerably well marked. There is pain in the articulation; the motions of the arm, especially upwards, are restrained; the shoulder is depressed, and approximated to the sternum; the arm apparently lengthened, and the projection formed by the outer end of the clavicle lying upon the acromion process, is very easily recognized beneath the skin. In partial dislocations the symptoms are similar, but much less marked.

Treatment.—If the shoulder is drawn backwards, and the outer end of the clavicle pressed upon, the bones are usually restored to their natural relation. There is always great difficulty in retaining them in position, owing to the flatness and obliquity of the articulating surfaces, as well as the contraction of the clavicular portion of the trapezius muscle; but fortunately, although exact coaptation may not be obtained, the ends of the bones appear to adapt themselves to their new conditions, and the utility of the limb is but little impaired. The shoulder must be fixed, and, in order to keep the scapula raised, and the outer end of the clavicle depressed, a stout compress should be placed upon the latter point, and retained by a broad band passed over it, and under the elbow of the same side, and tightened and fixed by a buckle. If greater pressure is required, a Petit's tourniquet, as used by M. Laugier, may be applied in the same manner. For the exact details of this arrangement, the reader is referred to special treatises on the subject;[1] but much must be left to the ingenuity of the surgeon in each individual case. [Much advantage will result from the application of the plaster-of-Paris roller, by means of which the displaced end of the clavicle may be quite well held in place.]

The second and third forms of this dislocation mentioned above are extremely rare. Only three unequivocal examples are recorded of the former, and there are some doubts as to the authenticity of the published cases of the latter.

Two instances have been reported of dislocation both at the sterno-clavicular and acromio-clavicular articulation in the same subject, or "*simultaneous dislocation of both ends of the clavicle;*" the first by Richerand, and the second by Morel-Lavallée.[2]

Dislocations of the Humerus.

The humerus is dislocated nearly as frequently as are all the other bones of the body together. The statistics of Malgaigne, and several other authors, assign a still larger proportion; but this arises from the fact that many of the luxations of smaller bones, as phalanges, are evidently omitted from their tables. Its relative frequency in the table at p. 845 is 53 per cent.

The peculiar structure of the shoulder-joint, the shallowness of the articular surface of the scapula, the large size and glob-

[1] Op. cit., p. 523.
[2] Operative Surgery, 2d edit., 1858, p. 94.]
[3] On Dislocations and Fractures, 1859.

[1] Especially Malgaigne, op. cit., tome ii., p. 440.
[2] Gazette des Hôpitaux, 1859, No. 33.

ular form of the head of the humerus, the very extensive movements and long leverage afforded by the arm, and its frequent exposure to injury in protecting the more important central organs of the body, are all circumstances which contribute to the facility and frequency of dislocation. On the other hand, the free mobility of the scapula has, to a certain extent, a counterbalancing influence.

Dislocation of the humerus is an accident chiefly met with in middle and advanced life; it is extremely rare during childhood and youth. A case was brought to the Middlesex Hospital (August 5, 1860) of a dislocation forwards, in an infant fourteen days old. The arm had been violently pulled and twisted. Mr. F. H. Watts, the house-surgeon, made such a careful examination as to leave no doubt respecting the nature of the injury, and on extension being applied, it was reduced with a characteristic snap.

Common as these injuries are, their pathology is still imperfectly understood, and great discrepancies exist in the classification and descriptions given by various writers who have directed their attention to them. The modern French surgeons particularly have arrived at very different conclusions to those generally adopted in this country, not only as to the usual situation of the head of the humerus, but in regard to several other important points, even in the most common forms of dislocation.

As want of precision in the terms used in describing the different varieties of luxation has hitherto been a principal source of obscurity, it will be necessary, before proceeding further, to adopt a definite and intelligible system of nomenclature. The obliquity of the glenoid fossa, and the variations in the position of the scapula, render such words as downwards, forwards, inwards, etc., very inefficient as distinctive designations of particular forms of dislocation. Names derived from the relation of the head of the bone in its new situation to important contiguous osseous structures are more concise, expressive, and definite. Adopting this method, all the possible dislocations of the humerus readily group themselves into the following five divisions:

1. SUBCORACOID.—Forwards and slightly downwards. On to the neck of the scapula, in front of the glenoid fossa, and immediately below the coracoid process. *Common.*

2. SUBGLENOID.—Downwards and forwards. Head of the humerus in front of the inferior costa of the scapula, below the glenoid fossa. *Rare.*

3. SUBCLAVICULAR.—To the inner side of the coracoid process; under the clavicle. *Very rare.*

4. SUPRACORACOID.—Upwards and forwards. On to the fractured coracoid process. *Only three cases reported.*

5. SUBSPINOUS.—Backwards. On to the back of the neck of the scapula, beneath the spine or posterior edge of the acromion. *Very rare.*

[Hamilton states: "My private and hospital records furnish me with 117 cases of dislocation of the shoulder, seen and recorded by myself. Of these, 41 were recognized as subglenoid, 83 as subcoracoid, a very small proportion as subclavicular, 2 as subspinous, and the remainder were not accurately diagnosticated."]

These names are all recognized in the system of Malgaigne; some of them may be not altogether free from objection, but it seems better to retain them than to run the risk of adding to the confusion by introducing new ones. For the sake of greater simplicity, the number of this author's divisions is reduced; his incomplete and complete subcoracoid and intracoracoid being included under one head, for reasons which I shall give presently, and his two forms of dislocation backwards being also classed together. Undoubtedly varieties are frequently met with intermediate between several of these forms, especially the first and second, but it appears unnecessary to give them separate names.

I shall commence with the description of the most common form.

1. *Subcoracoid.*—Under this term are included dislocations which Malgaigne considers as belonging to two distinct varieties, and which he respectively designates *subcoracoid* and *intracoracoid.* Although there are doubtless characters by which well-marked cases of either can be determined, the difference between them is slight, and being rather of degree than of form, I can see no practical advantage in retaining it in our classification. Perhaps, for the purposes of critical investigation, they might be regarded as sub-varieties of one common form. The main distinction between them seems to be this,—in both cases the groove between the articular head of the humerus and the great tuberosity, rests on the same part of the anterior edge of the glenoid fossa. If the posterior scapular muscles are entire, being put on the stretch, they cause the head of the humerus to be rotated outwards, and the *subcoracoid* variety is produced; if the injury has been inflicted with greater violence, and these muscles are separated from their attachments, or the greater tuberosity broken off, or if, perhaps from some other cause, their action is diminished, the humerus is allowed to turn more inwards, and the greater part of its head is placed internal to a line falling from the tip of the coracoid process, and the injury is called *intracoracoid.* The name "*subcoracoid*"

seems preferable for all these cases, as it is extremely expressive of the position of the head of the bone; while "*intracoracoid*" would have been more correctly applied to that form of dislocation in which it is truly on the inner side of the coracoid process, the one commonly called "*subclavicular.*"

Although quite unrecognized in the earlier, and only doubtfully admitted into many recent systematic works in this country, numerous cases of subcoracoid dislocation, in which the anatomical characters are accurately described, are to be found in the pages of our surgical treatises and periodicals. One of the earliest of these is the well-known case (now preserved in University College Museum) recorded by Thompson more than a century ago.[1] A reference to the figures in the quarto edition of Sir A. Cooper's work will show that at least one of the specimens from which he described the anatomical characters of dislocation *downwards* really belonged to this form; and that the description of the position of the head of the bone in the text must have been influenced by the previous opinions of the writer.[2] The same may also be said of the case cited by this distinguished surgeon, as an evidence of "partial dislocation." Many of the cases that have been published of dislocation forwards and inwards, or subclavicular, are nothing more than specimens of this variety. Of forty-one specimens of dislocation at the shoulder-joint preserved in the different anatomical musems in London, as many as thirty-one undoubtedly belong to this form;[3] and of fifty recent cases which have come under the observation of myself, or gentlemen in whom I can place perfect confidence, and of which I have full particulars, in forty-four the head of the humerus was placed so closely beneath the coracoid process as to justify the appellation of "subcoracoid." [As already stated (p. 869), Hamilton reports having met with forty-one cases of subglenoid and thirty-three of subcoracoid luxation.] In the face of these facts, it is difficult to understand how the widespread error of regarding the subglenoid as the typical form of dislocation at the shoulder-joint, should have been so long maintained. A simple process of reasoning upon the anatomical structure of the part would suffice to show that, whenever the humerus is thrown from its socket, it will almost of necessity be drawn upwards until it is arrested either by the coracoid process in front, or the spine or acromion behind. Even in the dead subject, when dislocation is artificially produced by forcibly elevating the arm, while the scapula is fixed, the humerus is almost always drawn up close against the under surface of the coracoid process; *a fortiori*, in the living, must the action of the deltoid, coraco-brachialis, and biceps cause it to assume this position. In fractures about the neck of the humerus, the action of these muscles in raising the lower fragment has long been recognized. The truth is, that nearly all the cases of dislocation "into the axilla," or "downwards," described as so common by Sir A. Cooper, and all subsequent British authors, have really been examples of this variety, to which the anatomical characters of the more rare "subglenoid" dislocation have been erroneously applied.

Subcoracoid dislocation may be produced either by a direct force applied to the upper part of the humerus, driving it forwards and inwards, as a blow or fall upon the shoulder; or, secondly, by forcible elevation of the distal end of the humerus, such as may be caused by a fall upon the elbow or hand, when extended from the body. In the forty-four cases above mentioned, the causes were as follows: falls or blows upon the shoulder, in eighteen; upon the elbow, in five; upon the hand, in ten; while in eleven cases the cause was of doubtful or exceptional nature, including two from muscular action. Of these, one took place in attempting to strike a violent blow at a man, who eluded the stroke; the other in putting on a coat. In the last case, however, the humerus had been frequently dislocated before.

Symptoms.—The patient complains of pain about the joint, especially on the inner part, along the course of the great nerves of the brachial plexus, sometimes extending down the arm as far as the fingers, and accompanied by a sensation of numbness. He is quite unable to move the arm at the shoulder; the elbow projects from the side, and cannot be made to touch the chest, at least without causing pain; it is sometimes carried rather behind, sometimes in front of the body, and is frequently rotated rather inwards, but occasionally outwards. [As originally demonstrated by Prof. Dugas, of Georgia, in all cases of shoulder-dislocation "it is impossible, while the elbow touches the thorax, to place the fingers of the injured limb upon the sound shoulder."] The movements of the forearm and hand are not impaired. On examining the shoulder more closely, and comparing it with the uninjured side, a striking change is apparent in its form—especially distinct, of course, if the patient is thin and no great inflammatory swelling has taken place. The natural roundness is lost, the acromion appears remarkably prominent, and beneath

[1] Med. Obs. and Inquiries, 1762, vol. ii., p. 340.

[2] Fifth edit., 1826.

[3] See a paper by Mr. Flower, Trans. Path. Soc., vol. xii.

it there is a depression into which the fingers can be pressed; and in some subjects even the form of the glenoid fossa of the scapula can be distinguished through the fibres of the deltoid. The axis of the humerus is evidently altered; instead of being directed to the glenoid fossa, it points to a spot internal, anterior to, and below it. The limb usually appears lengthened; but on carefully measuring from the acromion process to the external condyle, and comparing it with the opposite side, we find it frequently equal, or somewhat shorter. Of

Fig. 183.

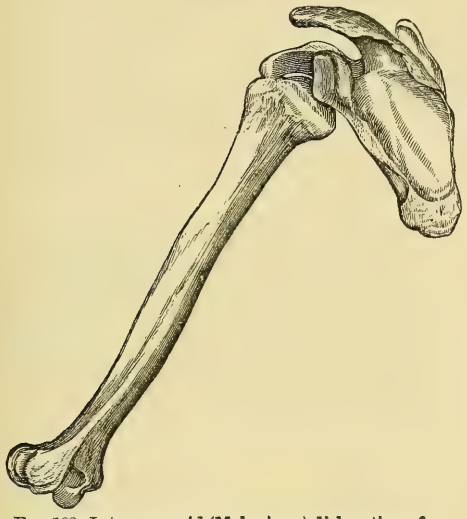


FIG. 183. Intracoracoid (Malgaigne) dislocation of humerus. From a model by Mr. Flower, in the Middlesex Hospital Museum.

forty-four cases of subcoracoid dislocation, the arm was elongated in nineteen, unaltered in eight, and shortened in seventeen; the greatest elongation being one inch, the greatest amount of shortening $\frac{7}{8}$ inch. Measurement of the vertical circumference of the shoulder, by carrying a tape over the acromion and under the axilla, always gives an increase of from one to two inches over the uninjured side; an important diagnostic sign, common to all forms of dislocation of the humerus, as pointed out by Mr. Callaway.[1] The anterior fold of the axilla is deeper and fuller than natural, the pectoral muscle being raised by a rounded swelling, which partly effaces the subclavicular fossa. On placing the fingers in the axilla, the upper and anterior part of this space is found to be occupied by the head of the humerus, here covered only by the integument, and moving readily with every movement communicated to the elbow. Or it may be that the upper part of the shaft only is felt at first in the axilla; but on raising the arm from the body, the globular form of the head can generally be detected.

Abundant opportunity is afforded in our museums of studying the effects of this accident, both in the recent state and when left long unreduced; and its usual anatomical characters can be ascertained with great precision when it is artificially produced in the dead subject.

The head of the humerus lies on the anterior surface of the neck of the scapula, immediately below the coracoid process, in front of, internal to, and rather lower than, its normal situation. That part of the anatomical neck which separates the articular surface from the great tuberosity rests upon the anterior edge of the glenoid fossa. The subscapular muscle is raised from the neck of the scapula, and stretched over the front of, or above the head of, the humerus. The muscles from the back of the scapula (supraspinatus, infraspinatus, and teres minor) are drawn tightly across the glenoid fossa, or one or more of them may be ruptured, or detached from the bone. A portion, or the whole, of the greater tuberosity is frequently separated, when it may be drawn into the glenoid fossa by the action of the muscles inserted into it, or may be retained in connection with the humerus by the periosteum, or the capsular ligament. The long tendon of the biceps is rarely, if ever, injured.[1] The muscles that descend from the coracoid process to the humerus are stretched by the projection of the head of the bone forwards, and the great vessels and nerves are displaced inwards. Occasionally the circumflex nerve is pressed upon to such an extent as to cause paralysis of the deltoid muscle.[2] Lastly, the capsular ligament is lacerated more or less extensively, anteriorly and inferiorly, the upper end of the humerus having escaped through the aperture.

When left long unreduced, important changes take place in the affected structures. Those that are common to all dislocations, as the formation of a new capsule and fibrous socket, need not be detailed here, but the peculiar alterations in the

[1] Dissertation upon Dislocations and Fractures of the Clavicle and Shoulder-Joint, 1849.

[1] As Dr. Hamilton has recently asserted that, "contrary to what has been affirmed by Sir Astley Cooper, the tendon of the long head of the biceps is often broken asunder, or detached completely from its insertion" (op. cit., p. 535), I may mention that the statement in the text is founded on examination of numerous specimens and reports of dissections.

[2] See a preparation in the Museum of St. Bartholomew's Hospital, A 42.

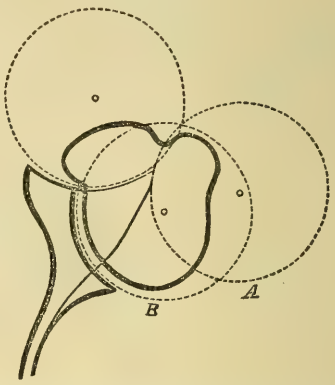
contiguous extremities of the two bones belong to the special part of the subject.

In process of time a new shallow socket is formed upon the anterior surface of the neck of the scapula, partly by absorption of old bone, and partly by deposit of new, around its edge. The exact position of this socket varies according to the degree of displacement of the humerus: in the first variety (*subcoracoid* of Malgaigne), the new cavity is formed more or less at the expense of the anterior portion of the glenoid fossa, which is gradually worn away, so that in some cases the original socket is finally almost entirely lost. A corresponding change takes place in the head of the humerus: where it rests upon the edge of the glenoid fossa, absorption occurs, so that a groove is excavated, usually between the articular head and the great tuberosity. With continued friction, this increases in size simultaneously with the changes in the scapula; the two accommodate themselves to each other, and ultimately the head of the latter bone presents a double articular surface, separated by a vertical ridge; the posterior portion being part of the old glenoid cavity, the anterior the newly-formed socket. These respectively articulate with the two sides of a wide groove placed vertically on the head of the humerus, and thus a rude kind of joint, which allows of a certain amount of motion, is formed. In consequence of the absorption that has taken place in both bones, the head of the humerus has by this time made considerable progress towards regaining the position it occupied before the injury, and therefore the external signs of dislocation become to a certain extent removed. The under surface of the coracoid process, especially near its tip, is almost always found smooth and eburnated, having entered into the formation of the new articulation.[1] If the head of the humerus is placed further under the coracoid process (*intracoracoid* of Mal-

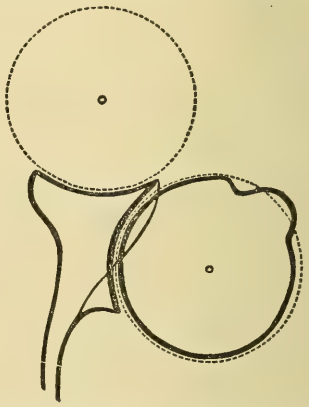
Fig. 184.

Fig. 184. Subcoracoid dislocation of humerus. From a model by Mr. Flower, in the Middlesex Hospital Museum.

Fig. 185.



Subcoracoid dislocation; first variety. The circle *A* shows the position of the head of the humerus in recent dislocations; *B* the same when left long unreduced, the new socket encroaching upon the glenoid fossa, the head of the humerus grooved by the pressure of the ridge between the old and new socket. Specimens in this condition have generally, but incorrectly, been described as "partial dislocation." From Mr. Flower's paper on the "Changes in the Shoulder-joint," etc., Path. Trans., vol. xii., p. 1863.



Subcoracoid dislocation; second variety (*intracoracoid* of Malgaine). New socket on front of neck of scapula, not encroaching on glenoid fossa; no grooving of the head of the humerus, but the greater tuberosity partially worn away. Ibid.

[1] Specimens which have presented these characters have generally been cited as examples of "partial dislocation."

gaigne), the new socket upon the neck of the scapula is formed quite outside the margin of the glenoid fossa, upon which it does not encroach. It is then a simple cup-shaped depression, and the head of the humerus undergoes none of the changes above described, but is generally worn away on the side of the greater tuberosity by the friction against the anterior edge of the glenoid fossa, and hence assumes a somewhat oval shape. In these cases the coracoid process is not usually a part of the new articulation. Between the two extremes, all intermediate varieties are found; the position of the new socket, quite free from, or more or less encroaching upon, the glenoid fossa, the head of the humerus unaltered, flattened on its outer side, or grooved, being circumstances which all depend upon the exact situation in which the bone has found its new lodgment. As in unreduced dislocations of long standing elsewhere, the surfaces of the bones which are in contact are generally divested of cartilage, and in places hard and polished.

As the history of the case is unknown in most of the museum specimens, it is difficult to determine the length of time required to effect these changes; probably it varies much under different circumstances. In a specimen in St. Bartholomew's Hospital Museum,[1] in which the accident is said to have occurred three months before death, absorption of the anterior edge of the glenoid fossa has already commenced, and some bone is deposited in the margin of the new socket.

2. *Subglenoid.*—As every intermediate condition may be met with between this and the last, it may be regarded as a variety of that common injury, in which the head of the humerus, instead of being drawn up against the coracoid process by the action of the muscles passing from the shoulder to the arm, has remained at some distance below this point.

According to Malle, the principal circumstance which prevents the bone ascending, seems to be that the anterior portion of the capsular ligament remains entire, rupture of the lower part only having taken place.[2]

In the most characteristic cases, the head of the humerus is thrown below the glenoid fossa, and rather forwards and inwards, resting upon the inner border of the inferior costa of the scapula, and may be felt very prominently in the axilla. The symptoms are much the same as in subcoracoid dislocation, but rather more marked. The depression beneath the acromion is greater; the arm is separated farther from the side, and is generally lengthened, but occasionally is unaltered in this respect, or it may be even shortened. This variation in length may be accounted for, partly by the uncertain position of the head of the humerus, which may be either close upon the edge of the glenoid cavity, or farther back in the subscapular fossa, and partly by the diminution of the distance between the acromion and the external condyle, dependent upon the projection of the elbow from the side.[1] On the whole, the length of the arm is little to be depended on as a diagnostic mark of dislocation. The main distinction between this and the last, is the interval, of from one to two fingers' breadth, felt between the coracoid process and the head of the humerus. [See FIG. 186, p. 874.]

The most common cause of subglenoid dislocation is a fall upon the hand or elbow; it rarely proceeds from a direct blow upon the shoulder.

In the only two specimens of unreduced dislocations of this kind that I have been able to find in the anatomical museums of London, a new osseous socket has formed for the head of the humerus on the upper part of the anterior border of the inferior costa of the scapula, encroaching considerably upon the lower and anterior part of the glenoid fossa. One of these[2] has been figured by Sir A. Cooper, and its subsequent reproduction by other authors has contributed much to confirm the error of regarding this as the usual form of dislocation of the shoulder. From examination of specimens in museums, and from numerous recent cases, I should conclude that not more than one in ten of all dislocations of the humerus can properly be called subglenoid.

3. *Subclavicular.*—"The head of the os humeri placed below the middle of the clavicle, and on the sternal side of the coracoid process." As the last may be regarded as a variety of the ordinary form of dislocation in which the head of the humerus is placed unusually low, so may this be considered as one in which it has passed farther than common in an inward and upward direction. The cases in which the position of the bone exactly corresponds to the above definition of Sir A. Cooper must be very rare indeed, although there are a sufficient number on record to prove

[1] C 103.

[2] "Mémoire sur les Luxations scapulo-humérales," Mém. de l'Acad. de Méd., tome viii., p. 595. See also Goyrand, "Nouvelles Études sur la Luxation en bas ou sous-glénoïdienne," Mém. de la Soc. de Chirurgie, tome i., p. 21.

[1] Well illustrated by a diagram in Callaway's Essay on the Shoulder-Joint, p. 109.

[2] Now in the Museum of St. Thomas's Hospital, B 11. The other is in the Museum of the Royal College of Surgeons, No. 3275. There is a specimen in King's College Museum (No. 1342) which is intermediate between subcoracoid and subglenoid.

the possibility of its occurrence. In one example described by Malgaigne, the head of the humerus was thrust between the deltoid and the pectoralis major, and was only covered in the interval by the integuments.

Fig. 186.

FIG. 186. Subglenoid dislocation of humerus. (From a model by Mr. Flower, in the Middlesex Hospital Museum.)

Fig. 187.

FIG. 187. Subclavicular dislocation. (From a model by Mr. Flower, in the Middlesex Hospital Museum.)

We know little of the anatomical characters of this injury, and there is no preparation in any of the London museums which exhibits them. In one specimen in St. Bartholomew's Hospital Museum,[1] the head of the humerus is said to have been "found resting on the subscapular fossa, and immediately below the clavicle;" but it has unfortunately been removed from this situation in putting up the preparation. In two cases of unreduced dislocation in another museum, in which the head of the bone is described in the catalogue as being "under the clavicle," the new socket is distinctly seen to be immediately below the coracoid process. This, I suspect, has been really the case in most of the so-called "subclavicular" dislocations which have been put on record. In consequence of the subcoracoid not having been recognized as a common variety, any dislocation that was not subglenoid, was necessarily supposed to be subclavicular.

The characteristic symptoms, according to Malgaigne, are as follows: the arm is pressed against the chest; it appears in some cases to be lengthened, in others shortened; the elbow is but slightly removed from the side, and points either directly outwards or somewhat backwards. (FIG. 187.) The head of the humerus is felt on the inner side of the coracoid process, making usually a very apparent projection forwards. Sometimes it is by no means so conspicuous, but lies deeply in the subclavicular fossa. It approaches the clavicle in some cases so nearly as to touch it. In the axilla the shaft is felt, but not the head of the bone, even when the arm is raised to a right angle with the body. The causes are either a violent blow or fall directly on the outside of the shoulder, or a fall upon the hand or elbow, pushing the humerus directly upward and inwards.

4. *Supracoracoid.*—Malgaigne founded this variety upon a single case, in which the head of the humerus appeared to be dislocated upwards and forwards, and rested upon the coraco-acromial ligament, touching externally the inner border of the acromion, internally the coracoid process, which it covered, and projecting under and raising the deltoid.[2]

More recently, Mr. Holmes has published an account of the dissection of a case where the coracoid process being fractured, the head of the humerus rested on its stump, and on the clavicle, fairly out of, above, and a little anterior to, the glenoid fossa, and, having passed through the fibres of the deltoid muscle, was only covered by the integument. The long tendon of the biceps was displaced to the outer

[1] Series iii., No. 55.
[2] Op. cit., tome ii., p. 530

side of the head of the bone. The preparation is now in the Museum of St. George's Hospital. In the same paper the symptoms of an apparently similar case, observed by Mr. Prescott Hewett, are described.[1]

5. *Subspinous.*—This is also a rare form of injury, but one of which the characters are so well marked, that it is not liable to be confounded with any of the others. There are four good specimens, illustrating its effects when left unreduced, in the anatomical museums of London. Out of 159 cases of scapulo-humeral luxation recorded at the Middlesex Hospital, three are assigned to this variety.

Malgaigne describes two forms of dislocation backwards, "subacromial" and "subspinous." As the former is only a less complete variety of the latter, it seems unnecessary to retain the distinction. The subacromial is undoubtedly the most common; but the name is objectionable, as it does not express any change from the normal situation of the head of the humerus.

Fig. 188.

Subspinous dislocation. (From a model by Mr. Flower, in the Middlesex Hospital Museum.)

The displaced head of the bone may rest either on the posterior edge of the glenoid fossa, on the back of the neck of the scapula, beneath the posterior angle of the acromion, or, more rarely, on the dorsum of the scapula below the spine. On dissection, the tendon of the subscapularis is generally found to be detached from the lesser tuberosity.

The symptoms vary according to the amount of displacement of the head of the bone, being proportionately more marked as this is farther removed from the glenoid cavity. There is always the flattening of the shoulder and prominence of the acromion, common to all luxations of the humerus. The head of the bone, covered with muscles, forms a marked protuberance on the back of the scapula, immediately under the posterior angle of the acromion; in front, between it and the coracoid process, is a considerable depression. The length of the arm is unaltered, or but slightly increased; it is generally applied closely to the side, and rotated inwards, with the elbow usually advanced. The most frequent causes of dislocation backwards, are falls either upon the shoulder, or upon the elbow when advanced. Violent twisting of the arm inwards has produced it, and so has, not unfrequently, convulsive muscular action in a fit of epilepsy.

Partial dislocations.—Sir A. Cooper and most of his contemporaries believed in the existence of these injuries, but many recent surgical authors doubt even the possibility of the head of the humerus being retained in the position indicated by the term "partial dislocation," unless under very exceptional circumstances. Malgaigne, rejecting the greater number of cases previously brought forward, as being examples, either of complete luxation, or of pathological changes in the articulation, has described several, which appear to him conclusive instances of "incomplete subcoracoid dislocation." But these cases are not, in my opinion, either in their symptoms or post-mortem appearances, sufficiently distinct from the ordinary form of the injury to warrant our placing them in a separate division. I am therefore disposed to agree with Dr. R. Adams in denying "that the case of partial luxation of the head of the humerus, as the result of accident, has ever been satisfactorily proved, either in the living or the dead subject."[1]

Treatment.—The great majority of cases of dislocation of the humerus, when recent, are reduced by the skilful surgeon without difficulty. It is only where the injury is of such long standing that the parts have become rigid, and are beginning to adapt themselves to their new state, or in some of the more unusual positions of the bone, that any mechanical aid need be brought into requisition. The method of treatment which is best adapted for the ordinary forms of scapulo-humeral dislocation will be considered first, and the special modifications required for the rarer varieties will be mentioned afterwards.

The use of chloroform [or ether] has now superseded all the agents formerly employed

[1] Medico-Chirurg. Trans., vol. xli., p. 447.

[1] Art. "Abnormal Conditions of the Shoulder-Joint," Cyclop. Anatomy and Physiology, vol. iv., p. 606.

to produce a lax condition of those muscles which, by their spasmodic contraction, often present so great an obstacle to the reduction. Whether it is administered or not in any individual case, will depend upon the condition of the patient, and the estimate placed by the surgeon upon the value and the danger of this powerful agent. In recent dislocations, when the patient is of average size and muscularity, it is not usually required, at all events not until after an attempt at reduction by the usual methods has failed, and some more severe means have to be put into operation. In persons of great muscular power, and especially if two or three days have elapsed since the injury, its administration will be advisable. After a longer period, no attempt at reduction should be made without it, not only on account of the saving of pain, but because it renders the chances of success far more favorable.

In very relaxed subjects, especially if it is not the first time of the occurrence of the injury, it sometimes happens that a slight movement of the limb on the part of the surgeon will effect the reduction. Either while lifting the arm from the side or in pressing upon the head of the bone with the fingers in the process of examination, it is felt to go back into its place with a slight snap. But in most cases it is held in its new position with such an amount of firmness as to require that further measures should be taken. Nearly all surgeons who have approached the subject scientifically have agreed, both from reasoning and experiment, that the direction which most favors reduction of the humerus, both by obviating mechanical obstacles and by relaxing the tension of the numerous muscles that pass to it from the scapula, is one in which the axis of the bone shall be a line exactly perpendicular to the surface of the glenoid fossa, which line, if prolonged backwards, is nearly coincident with the lower border of the spine of the scapula. In all the most successful methods of reduction the traction is in reality exercised more or less in this line, although, if the scapula is regarded as a fixed instead of a movable point, it may seem otherwise. But, in fact, so much can this bone turn upon its axis, that, whether in the method of pulling the humerus upwards, advocated by White and La Mothe, horizontally outwards, recommended by Malgaigne, or downwards with the heel in the axilla, so generally adopted by Sir A. Cooper and most surgeons in this country, although the line of traction appears so widely different as regards the body of the patient, yet the two points with which we have specially to deal, viz., the glenoid fossa and head of the humerus, are not far different in their relation to each other. The importance of the mobility of the scapula in facilitating the reduction of dislocations, hitherto much overlooked, has been particularly pointed out by Mr. Skey.[1]

When we have a recent case to deal with, in which we do not anticipate any particular difficulty, we may commence with the following, as the simplest method of reduction. The patient, seated on a chair, may be led to believe that the examination is still going on, so that no extraordinary effort of resistance on his part takes place; for if he is prepared for what he believes must be a serious operation, the muscles are often involuntarily rendered tense. The surgeon, standing behind or before the patient, as is most convenient, places his left hand upon the shoulder to steady it, and with the other, grasping the arm a little above the elbow (which should be flexed in order to relax the biceps), raises it rather above the horizontal line, giving it a slight rotatory motion inwards, combined with moderate extension; at the same time, with the fingers or thumb of the hand which is placed upon the shoulder, the head of the bone may be pressed backwards and upwards into the glenoid cavity. In this way, dislocations may often be reduced without any assistance. Without altering the position of the patient, the surgeon may gain more power over the humerus by placing his foot upon the side of the chair, and pressing his knee into the axilla, by which means he will get some counter-pressure against the wall of the chest, and firmer leverage, to raise the upper end of the humerus into its place.

In the event of failure by these simple methods, another plan in which, although the direction of the humerus is not quite so advantageous, a very effectual means of counter-extension is obtained, and which also has the merit of requiring no assistance, may be tried. The patient is placed upon his back upon a couch, and the surgeon, seated by the affected side, places his heel (the boot being removed) well up into the axilla, pressing upon the lower border of the scapula; grasping with both hands the lower part of the forearm, and leaning himself backwards, he draws the limb steadily downwards; the heel being at the same time made to press the head of the bone outwards. Directly it is felt to slip back into the socket, the extension should cease, and the forearm be brought across the chest.

If the humerus still resists, the following plan, which I have never known to fail in a recent dislocation, may be tried. The patient is seated on a high chair, which is placed about two feet from the post of an open doorway. The surgeon, leaning his

[1] Operative Surgery, 2d edit., 1858, p. 105.

back against the door-post, places one foot upon the side of the chair, and, with his knee pressed into the axilla, and both hands upon the shoulder, steadies the patient's body. A jack-towel is then fixed by a clove-hitch knot to the patient's arm, just above the elbow; and by its means two or more assistants, placed on the other side of the doorway, make steady extension horizontally outwards. Counter-extension from the opposite wrist has been advocated in America.[1] [Nathan R. Smith's method.]

It is scarcely necessary to say, that in all cases the traction must be gradual, steady, and continued, never violent or sudden; and as these conditions can be obtained more surely by means of the pulleys than by the exertions of assistants, in old-standing cases, where not only the resistance of muscular spasm has to be overcome, but fibrous adhesions have also to be broken down, it will be necessary to resort to these aids. The extending power is fastened either to the lower end of the humerus or to the forearm just above the wrist, and the shoulder is fixed by towels or straps passed under the axilla, and made fast to a staple in the wall. As the usual arrangements for counter-extension have the great disadvantage of compressing the walls of the axilla, and so making tension upon the pectoralis major and latissimus dorsi muscles, which ought to be relaxed, Mr. Skey employs a well-padded iron knob, from which two strong branches of the same metal extend laterally, each about four inches in length, ending in a bulb or ring, the office of which is to keep the margins of the axilla as free from pressure as possible, and to which the cords from the staples are attached; the iron knob is passed high into the axilla, and acts as the heel in the ordinary operation.[2]

In a case of twenty-five days' standing, which resisted all attempts at reduction by extension, Mr. Cock, at Guy's Hospital, adopted the following plan: "An air-pad made of vulcanized india-rubber was placed in the axilla, and the arm firmly bandaged to the side; the air-pad thus being made to exert a powerful outward pressure upon the head of the bone. Upon removing the bandage upon the third day, the head of the bone was found to have returned to its natural position."[3]

Dislocations downwards or backwards may be reduced upon much the same principles as those under the coracoid process; in the latter case the traction should be made in a somewhat forward direction. The true subclavicular dislocation is the most difficult to manage, and has sometimes resisted every attempt at reduction, even in the hands of the most experienced surgeons. To disengage the head of the humerus from the coracoid process, it will have to be drawn downwards and forwards.

When reduction has been accomplished, the joint should be kept at rest for two or three weeks, the arm being placed in a sling with the elbow lightly bound to the side, and all violent exercise prohibited for several months, as a comparatively slight cause may produce a second dislocation. Hamilton, who has given us many valuable observations upon the results of dislocations, makes the remark, that "the head of the humerus sometimes remains for a long time after the reduction has been effected, slightly advanced in its socket, so as to lead to a suspicion that it is not properly reduced;" and states that the probable explanation of this circumstance is, that "the long head of the biceps has been broken or displaced."[1] I think that it should be attributed rather to injury of the posterior scapular muscles, which, as before mentioned, suffer more frequently than the tendon of the biceps.

In cases that have been neglected, it often becomes a question whether we are justified in attempting a reduction, or whether the head of the bone should be left with the new connections it has formed, undisturbed. [In a case of 14 months' standing, Mears, of Philadelphia, subcutaneously divided the humerus at the middle of the surgical neck. "The wound closed in three days without suppuration," and three months later it was found that a false joint had been formed, permitting of free movement in every direction.] On this point the surgeon must exercise his judgment in each particular case; but, as a general rule, the limit laid down by Sir A. Cooper, of twelve weeks, may be taken as a guide. Many surgeons have, indeed, ventured much farther, and cases are reported of successful reductions after twelve, and even eighteen, months; but it must not be forgotten that we know less than we should do of the serious accidents which have often attended such attempts, one of the most frequent of which is laceration of the axillary artery. Already a considerable list of fatal cases from this cause might be collected.[2]

[1] See F. H. Hamilton, op. cit. [6th ed.], p. 646.
[2] See figure in Skey's Operative Surgery, 2d edit., p. 106.
[3] Bryant, Diseases and Injuries of Joints, 1859, p. 227.

A case of this kind was published by Mr. Callender, in the second volume of St. Bartholomew's Hospital Reports, 1866, p. 96. A gardener fell from a roof to the ground, and dislocated his left humerus. The dislocation was reduced, but was afterwards reproduced by an

[1] Op. cit. [6th ed.], p. 657.
[2] See Hamilton, op. cit., p. 554.

incautious movement of the arm. At the end of the sixth week he was sent into the hospital, where the head of the humerus was plainly felt in the axilla, drawn up towards the coracoid process. It was reduced, under chloroform, with the exercise of very slight force, by circumducting the arm. Directly afterwards a swelling rapidly rising and projecting the pectoral muscle was noticed, and as it did not pulsate and the radial pulse beat naturally, it was thought that the swelling might be due to the rupture of a vein or of a muscular artery. As the swelling continued to increase and the limb was greatly ecchymosed, it was laid freely open, and after turning out a large quantity of clot, a stream of arterial blood was seen to issue from a small round hole in the upper wall of the axillary artery. This vessel was tied above and below the orifice. Gangrene of the limb ensued, and the man died with symptoms of pulmonary embolism. [Hamilton gives a résumé of nineteen cases of arterial rupture, two of rupture of the axillary vein, one of both artery and vein, one in which the artery and quite probably the vein was also torn.]

Compound dislocation at the shoulder-joint is extremely rare, although cases have been met with in which the head of the humerus has been driven through the skin. It still remains to be determined by experience, whether under such circumstances reduction, or resection of the head of the bone, is the safer method of treatment. The latter practice is most likely to be followed by success, if we may draw inferences from the results that have been obtained by its adoption in similar injuries to other articulations.

When fracture of the shaft accompanies dislocation of the head of the humerus, the bone should be firmly put up in straight splints, and chloroform [ether] being administered, reduction should be attempted by the usual methods. Dislocations combined with fractures of the neck are often impossible to reduce, and, as several preparations in our museums show, they then terminate either in union in the new position, or in the formation of a false joint between the fractured ends—in either case accompanied by shortening of the limb. Since the introduction of chloroform, however, more favorable results have been obtained in these cases; for when the muscles are thoroughly relaxed, and gentle extension is made on the shaft, the head of the bone can often be manipulated back into its socket. Then it must be fixed by a pad in the axilla and a gutta-percha splint over the shoulder, before the recovery of the patient from the anæsthetic allows the muscles to resume their spasmodic contractions.

Among the rare complications of dislocated humerus may be mentioned rupture of the axillary artery, of which a case is related by Dr. R. Adams. It was recognized by the diffused aneurismal swelling in the axilla, and absence of pulse at the wrist. After the dislocation was reduced, the subclavian artery was tied, and the patient recovered.[1]

Occasionally both humeri are dislocated at the same time. A man was brought recently to the Middlesex Hospital, to whom this had occurred in falling into a cellar, with both arms stretched out before him.

Dislocations of the Ulna and Radius at the Elbow-joint.

Though dislocation of the humerus rarely occurs before the age of twenty, the bones of the forearm are especially liable to this accident in childhood and youth. More than one-half of the cases of dislocation at the elbow, in the statistical table at p. 845, occurred in boys between the ages of five and fifteen. Of seventy-two cases observed by Dr. F. H. Hamilton, twenty-nine were in children under fourteen years of age.

Malgaigne concludes, from experiments upon the dead subject, and from careful examination and interrogation of patients who have met with this accident, that the most frequent cause of nearly every form of luxation at the elbow-joint, is a twist given to the ulna, which brings the coronoid process successively inwards, downwards, and backwards, and which may be produced by a fall upon either the internal border of the forearm, or the inner side of the olecranon. Other authors state that this injury is more frequently occasioned by a fall in which the palm of the hand comes into violent contact with the ground, so that the forearm is driven directly back under the lower end of the humerus.

The bones may be displaced backwards, forwards, or to either side; besides these, there may be intermediate forms, as backwards and outwards, backwards and inwards. Each form may be incomplete, or complete; and as exceedingly rare varieties may be mentioned, dislocation of the ulna alone backwards, the radius remaining in its normal situation, and a dislocation of both ulna and radius, in which the former is displaced backwards and the latter forwards, with reference to the lower end of the humerus. There may also be the complication of fracture of the olecranon or coronoid process of the ulna, of either of the condyles of the humerus, or of the head of the radius, or the dislocation may be compound. Much swelling of the arm often follows these accidents, frequently masking their special characters, and rendering it difficult to establish an accurate diagnosis.

The only one of the above-named varieties which is at all common, is *dislocation*

[1] Cyclop. Anat. and Phys., art. "Shoulder, Abnormal Conditions of," p. 616.

of both bones of the forearm backwards. When this is complete, the coronoid process (if not fractured) is lodged in the olecranon fossa of the humerus. According to Malgaigne, this condition is not so common as the incomplete form, in which the process rests upon the trochlea of the humerus. The radius almost always maintains its relative position to the ulna, being held by the orbicular ligament. The anterior and two lateral ligaments of the elbow-joint are generally torn.

The following symptoms accompany dislocation backwards, when in its most complete and characteristic form. The whole arm appears shortened. The forearm is slightly flexed and pronated; it can be moved from side to side upon the humerus, if that bone be fixed. The elbow exhibits a marked deformity, being increased in its antero-posterior diameter. The olecranon is carried backwards and upwards, so that its point is above the condyles of the humerus; the tendon of the triceps attached to it is rendered very prominent. On the external side the head of the radius, carried entirely behind the humerus, can be recognized rolling upon the ulna when the hand is rotated. Anteriorly the lower end of the humerus forms a prominence, over which the tendons of the biceps and of the brachialis anticus muscle are stretched.

The various *lateral* displacements may readily be recognized by the deformity of the elbow occasioned by the new relations of the bones to each other. Dislocation outwards is much more frequent than in the opposite direction.

The luxation *forwards* is extremely rare, and yet it has been met with, both in the incomplete and complete form; in the former the summit of the olecranon rests against the inferior part of the trochlea of the humerus, and the radius is below and somewhat separated from the external condyle; the prominence of the olecranon posteriorly has disappeared, and on each side the condyles of the humerus are unusually prominent, with a depression below them; the arm is elongated. In the complete dislocation all the above characters are present in a more marked degree.

Treatment.—The reduction of dislocations at the elbow-joint is not generally attended with much difficulty, and, with slight modifications, which will readily suggest themselves to the surgeon upon consideration of the anatomy of the joint, is conducted on the same principle for all the varieties. The method recommended by Sir A. Cooper, and which is generally adopted, is as follows: The patient sits upon a chair, and the surgeon, resting his foot upon the edge of the seat, places his knee upon the inner side of the elbow-joint, while he grasps the wrist with his hands; he then bends the elbow slowly, but forcibly, at the same time pressing with his knee upon the upper part of the ulna and radius, so as to disengage their articular surfaces from the lower end of the humerus. This method has the advantage of not requiring an assistant; but where help can be procured, extension of the forearm directly downwards, as advocated by Mr. Skey, is to be preferred; one person holds the upper arm, while one or more pull steadily at the wrist, and as soon as the coronoid process is brought below the level of the trochlea of the humerus, the action of the muscles bearing upon it, causes it to slip up into its natural place. The after-

Fig. 189.

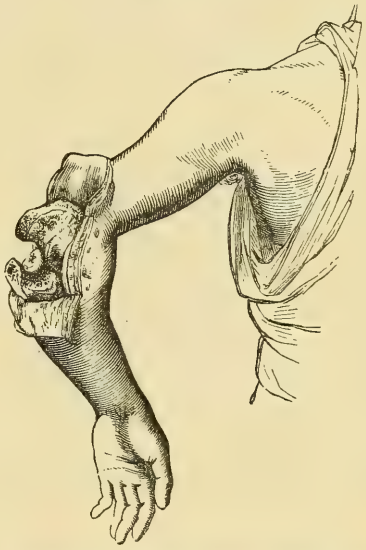


Fig. 189. Compound Dislocation of elbow (from a preparation; amputation. Fergusson).

treatment consists in keeping the arm in the bent position in a sling for two or three weeks, adopting the usual methods for preventing too great inflammatory action, and cautiously commencing passive motion in ten or fourteen days. If as much as a month or six weeks have been allowed to elapse before reduction, great difficulties will be met with. There are, however, cases on record in which it has been successfully performed after five or six months. On the other hand, frequent failures, severe accidents, and even death have been the consequences of such attempts. [For the relief of these cases, exsection of the elbow has in many instances been made. Fracture or subcutaneous division with saw or chisel of the olecranon is often all that is required to permit of reduction of the dislocation. Trendelenburg has recently reported a case in which he successfully

made a temporary resection of the olecranon; the separated piece, after the reduction, being replaced and attached to the ulna by steel-wire sutures.]

In *compound dislocations* at the elbow-joint, if there be extensive laceration of the soft parts, with lesion of the great vessels and nerves of the limb, amputation may be required. In most cases, however, it will be only necessary to enlarge the wound, to remove the articular ends of the bones, and trust to the formation of a fibrous joint. Although these are the rules for the treatment of such injuries generally laid down in modern surgical works, there are certainly cases in which neither of the above proceedings are necessary. If the patient is of healthy constitution, and the external wound not large, nor accompanied by any great amount of contusion, reduction may be effected, the wound closed, and cold water or other antiphlogistics assiduously applied.

In a case thus treated under my care, the patient (a laboring man, aged thirty-four) had fallen from a height of twenty feet upon a boarded floor. The bones of the left forearm were dislocated backwards and outwards, and there was a wound between the olecranon and the internal condyle sufficiently large to admit the finger into the joint, and through which a considerable portion of the cartilaginous surface of the trochlea of the humerus could be distinctly seen. But little inflammatory action took place; the wound healed rapidly; in a fortnight passive motion of the elbow was commenced, and in less than two months the use of the joint was perfectly restored.[1]

For further observations upon the treatment of injuries of the elbow-joint complicated with wound, see p. 843.

Dislocations of the Head of the Radius.

The head of the radius is sometimes displaced from its connections with the lesser sigmoid notch of the ulna, and the capitellum of the humerus. This injury usually occurs at an early age, and has been observed in very young infants. The causes are, either a fall in which the palm of the hand, coming in violent contact with the ground, communicates the shock to the radius in such a manner as to cause the upper end to start from its attachments, or a fall upon the elbow itself, or a violent pull on the radius, as when young children are suddenly lifted off the ground by the hand.

The head of the radius may be displaced in either of three directions,—forwards, backwards, and outwards; the first by far the most common, the last extremely rare. In any of these the displacement may be complete or incomplete; in the former condition, the orbicular ligament appears always to be ruptured; in the latter, it may be only stretched.

In the dislocation *forwards*, the head of the radius lies on the front of the external condyle of the humerus. The following are the most characteristic symptoms. The forearm is fixed in a slightly flexed state, either prone or midway between supination and pronation. Bending of the elbow is prevented by the head of the radius coming in contact with the front of the humerus, and complete extension causes pain. The head can be defined in its new position, and when the hand is rotated, it will be felt to move. The whole forearm has a peculiar and characteristic twist, occasioned by the altered situation of the upper end of the radius.

Dislocations backwards, or outwards, are distinguished by the head of the bone being felt subcutaneously in these positions. They are often accompanied by fracture of the external condyle.

Treatment.—Whatever be the nature of the displacement, direct extension from the hand will be found the most efficient means of reduction, combined, if necessary, with pressure by the fingers upon the projecting head of the bone in the required direction. The arm should then be put up in a gutta-percha splint. If, in consequence of the rupture of the annular ligament, there is difficulty in maintaining the head of the radius in its place, a firm pad must be fixed upon it. After dislocation forwards, caution must be used in straightening the arm for the first time; for if the ligaments are not perfectly united, the action of the biceps upon the radius may reproduce the displacement.

Dislocation of the Lower End of the Radius from the Ulna.

Sir A. Cooper, Malgaigne, and Hamilton describe this injury as a dislocation of the lower end of the ulna from the radius; but, following the analogy of the nomenclature commonly received in other cases, it is preferable to call it, with Desault and Skey, a dislocation of the radius. The ulna is the fixed bone, the radius moves upon it; and it is by an abnormal increase of the natural motion of this bone that the displacement is produced. It may be caused by an injury which produces excessive pronation or supination of the hand; in the former case, the radius is dislocated forwards, the hand accompanies it, and the lower end of the ulna projects prominently backwards beneath the integument: this is rather the more common of the two; in the other the position of the bones is reversed. This luxation is not unfrequently accompanied by fracture of the radius, and cases are recorded in which the styloid pro-

[1] See Lancet, 1860, vol. ii., p. 360.

cess of the ulna has been thrust completely through the skin.

In whichever direction the dislocation has taken place, it is to be reduced by extending the hand, and pressing the radius and ulna into their natural relations to each other. They must then be retained by a compress, and straight splints should be applied for a time to the dorsal and palmar surfaces of the wrist.

Dislocations of the Wrist.

Dislocation of the hand from the lower end of the radius and ulna, though described by all surgical authors, from the time of Hippocrates till the commencement of the present century, as of frequent occurrence, is now known to be an extremely rare injury. Fractures of the inferior extremities of the bones of the forearm were generally mistaken for it, an error which was pointed out first by Pouteau, but more fully by Dupuytren. When it does occur, it is usually compound, or is associated with fracture of some portion of the lower end of the radius or ulna. A fall upon the hand is the common cause of this injury.

The displacement may be in either of two directions, backwards or forwards. In the dislocation *backwards*, the whole hand is placed on a plane posterior to the forearm; the upper end of the carpus forms a prominence on the dorsum of the wrist, and the lower end of the radius and ulna project on the palmar surface. The chief diagnostic mark between this injury and fracture of the lower ends of both bones of the forearm is derived from carefully noting the position of the styloid process of the radius and ulna, which in the one case will remain with the forearm, and in the other be carried backwards with the hand. Measurement also along the back of the hand, from the upper part of the carpal projection to the end of the middle metacarpal bone, in dislocation will give only the length of the carpus and metacarpus of the opposite side, while in fracture there will be at least an additional half-inch belonging to the separated fragments of the bones of the forearm. Now that the pathology and symptoms of fracture of the lower end of the radius alone are so well understood, there will be no probability of its ever being confounded with a luxation of the carpus. See pp. 861 et sqq.

In dislocation *forwards* the hand is displaced to the palmar side, and the inferior extremities of the radius and ulna form a well-marked projection upon the dorsum. This accident is one of excessively rare occurrence, although in the malformations known as "congenital dislocations" of the wrist, the displacement is far more frequently in this direction than in the other.

Treatment.—Reduction is effected by simple extension, aided by pressure upon the carpus in the required direction. The hand should then be suspended in a sling until the ruptured ligaments have reunited; splints may be used if there is any difficulty in retaining the bones in good position.

Dislocations of the Bones of the Carpus.

The head of the os magnum occasionally suffers a partial luxation from the cavity formed for it by the scaphoid and semilunar bones. This is caused by violent flexion of the wrist, as in a fall upon the back of the hand. The unnatural projection on the dorsum of the carpus is easily recognized, and the bone may be pressed back into place, though it is retained with difficulty. A firm compress must be worn over it for some time.

Similar dislocations of some of the other carpal bones have been met with. Erichsen records cases of this injury to the semilunar and to the pisiform bone. The latter "was displaced by an effort to lift a heavy weight, and drawn up the arm to a distance of nearly an inch by the flexor carpi ulnaris."[1]

In the Museum of St. George's Hospital is a curious specimen of compound dislocation of semilunar bones of both sides, occasioned by a fall upon the hands from a great height. The bones were completely forced from their situation, through a wound on the anterior surface of the wrist, one of them merely hanging by a small shred of ligament.

A case is reported by Maisonneuve of simple dislocation backwards of the second row of carpal bones from the first, caused by a fall from a height of forty feet. The nature of the injury was verified by dissection.[2]

Dislocations of the Thumb.

Dislocations of the bones which compose this member are by no means unfrequent, as it is much exposed to injury in falls upon the hand. They may take place at either of its three articulations, and be either backwards or forwards, the former being by far the most common.

1. *Dislocation of the first bone of the thumb (metacarpal) from the os trapezium.*—This is less common than that of either of the other bones; it has been met with in both directions, and has generally been reduced without much difficulty by simple extension, though splints are sometimes required to maintain the bone in position. It may be mentioned here that a very few cases are on record of a partial luxation backwards of the proximal ends of some of the other metacarpal bones. F. H. Hamilton met with two; both produced in striking a blow with the clenched fist, and in each

[1] Op. cit., p. 281.

[2] Mém. de la Soc. Chirurg., tome ii.

of which the bones corresponding to the index and middle fingers were affected.[1] [In his last edition this author says that "several cases" have come under his notice. In one of them all the metacarpal bones except that of the thumb were dislocated by the passage of a musket-ball across the back of the hand "between the last row of carpal bones and the skin." In this case five years after the injury "the motions of all the fingers except the index and little fingers were unimpaired."]

2. *Dislocation of the first phalanx from the metacarpal bone.*—This injury is of more frequent occurrence; it is usually in the backward direction, *i.e.*, the proximal end of the first phalanx lies on the dorsal surface of the distal end of the metacarpal bone. The deformity of the articulation is so well marked, that the diagnosis is unattended with difficulty. The cause is generally either a fall or a blow upon the end or the palmar surface of the thumb.

Treatment.—In many cases reduction is effected without any great difficulty, either by seizing the phalanx with the thumb and finger and making extension, or by forcibly bending it backwards and pressing upon the displaced extremity with the thumbs, while the flexor brevis pollicis is relaxed by flexing the metacarpal bone as much as possible into the palm. If these methods do not suffice, greater extending power may be gained by fixing a piece of tape or strong twine round the phalanx, by a clove-hitch knot, a wetted bandage or strip of adhesive plaster having been previously applied to protect the skin.

After a fair trial of all the above measures, reduction has still been unaccomplished in so many cases, that both the cause of the difficulty and the means by which it ought to be overcome have become a standard subject for research and speculation among surgeons of all countries. It will suffice here to say that, although much difference of opinion has certainly existed upon this point, the majority of writers have agreed that the flexor brevis pollicis muscle is in some way the chief obstacle to reduction. Dissection of dislocations artificially produced on the dead subject, shows that when the phalanx is completely carried on to the dorsal surface of the metacarpal bone, the two attachments of the flexor brevis, with their contained sesamoid bones, slip over its wide head, and tightly embrace its neck. It is evident that the bone can only be disengaged from this situation with difficulty. The only successful way hitherto devised to overcome this, is the subcutaneous section of one, or even both of the tendons of the muscle. The cause of occasional failure of even this somewhat severe proceeding is, I believe, the difficulty of effecting a complete division of all the opposing fibres. I have found, in the dead subject, that a division of the fascia which connects together the two sesamoid bones, by allowing the tendons to separate from each other, quite up to their insertion, materially facilitates reduction, without resorting to the section of the muscle itself; but I have not yet had an opportunity of trying this on the living. Dr. Humphry, also on anatomical grounds, recommends an endeavor to draw the sesamoid bones forwards, by means of blunt hooks inserted through an incision in the skin.[1]

In dislocation of the first phalanx forwards, reduction has always been easily accomplished, generally by forcibly flexing the thumb towards the palm.

3. *Dislocation of the ungual phalanx.*—In this case the principal obstacle to reduction is the difficulty of getting a firm hold of the small displaced bone. Pressing its projecting proximal extremity forwards with the two thumbs will often reduce it, or the tape may be applied immediately above it, and then extension made, or it may sometimes be returned to its place by forcible flexion. Hamilton recommends "forced dorsal flexion in the case of the backward luxation, and forced palmar flexion in the case of the forward dislocation."

Dislocations of the phalanges of the fingers occur less frequently than those of the thumb. They are usually in the backward direction, owing to the mode in which the force is applied in falling on the end of one of the fingers, the most common cause of these accidents. The nature of the injury is readily recognized, and the reduction effected by simple extension applied in the manner recommended for dislocation of the phalanges of the thumb.

[1] Op. cit., p. 607.

[1] On the Human Skeleton, 1858, p. 435.

INJURIES OF THE ABDOMEN.

By George Pollock, Esq.

Revised by John T. Hodgen, M.D., LL.D.

Injuries of the abdomen are accidents generally of a grave character, with the effects of which the surgeon has frequently, but too often hopelessly, to combat. To insure a careful and a comprehensive examination of the nature and the results of these injuries, it is intended to consider the following points:

a. Contusion of the parietes.
   1. Without rupture of viscera.
   2. With rupture of viscera.

b. Wounds.
   1. Wounds of the parietes without protrusion of viscera.
   2. Wounds with protrusion of viscera.
   3. Wounds of viscera.
   4. Fistulæ; gastric and biliary.
   5. Artificial anus.

c. Foreign bodies in
   1. The stomach.
   2. The intestines.
   3. The cavity of the peritoneum and in the abdominal wall.

Contusions.

Contusion of the parietes of the abdomen, without rupture of any of the abdominal viscera, may prove, according to the violence of the injury, of serious importance, or trifling in effect. But even a slight contusion of the abdominal wall must not be regarded too lightly. A very slight blow on any portion of it may produce symptoms sufficient to excite alarm, or demand most careful consideration in treatment; and therefore in any case of a blow or other violence received on the abdominal wall, the examination of the patient should be conducted with extreme caution and judgment, in order that the *utmost* amount of mischief that may possibly result from such an accidental cause should not be overlooked. In such an examination it should ever be borne in mind, that the previous general condition of the part injured will, to a certain extent, influence the results; and that in judging of these results we must look to many relative circumstances: whether the abdomen be thickly covered with fat, or diminished in size by general emaciation; whether the contents of the stomach and intestines be considerable in quantity, or whether the accident has occurred some hours after a meal. These and other circumstances should be fully inquired into, and considered, before we decide on the probability, as well as on the extent, of deepseated mischief. Nor will it prove a small satisfaction if we can arrive at something like a favorable conclusion that the bruise of the integuments is not attended by rupture of any viscus.

Contusions of the abdominal wall (in which term we include merely the soft tissues surrounding the cavity of the abdomen) are various in their primitive, as well as in their subsequent, conditions. Such contusions are usually the result of falls or blows on the abdomen; of cart-wheels passing over the body; of shafts of carts or carriages forced against it; or of a quoit or cricket-ball striking it. Such accidents will frequently be immediately followed by intense pain, faintness, and vomiting, without any injury having occurred to the deeper tissues.

A quoit, in falling towards the ground, accidentally struck a boy on the epigastrium. The pain immediately experienced was agonizing for some seconds, and was attended by great difficulty in breathing. The boy was very faint subsequently. Rest on a sofa for the afternoon was the only treatment adopted, and on the following day he appeared quite well, nor did any ill effects ensue.

There appears to be a prevalent and a rather popular idea, that *sudden* death may result from a blow on the epigastrium or abdomen, without any injury of structure, external or internal, being detected on examination after death. It is therefore very desirable to inquire if any evidence we possess justifies us in accepting the statement, that death may follow *immediately* upon a blow, without any actual appreciable alteration or injury of parts contained within the cavities of the abdomen or thorax. It is not disputed for a moment that a very violent concussion of the abdominal viscera may be *rapidly* followed by death; but a very violent concussion would act, not only as a *shock* to the nervous system, but would also, without doubt, pro-

duce marked evidences of injured tissues, readily recognized on examination after death. But are there not cases of sudden death reported to have followed blows on the abdomen, in which cases no evidence of altered tissue nor any indications of bruise could be found? This question we fear we cannot answer quite satisfactorily. "There is no medical doubt that a person may die from what is termed shock," says Dr. Taylor, "without any marks of severe injury being discovered on the body after death. We have examples of this mode of death in accidents from lightning, or from severe burns or scalds, in which the local injury is often far from sufficient to explain the rapidly fatal consequences. As instances of this form of death from violence may be also cited those cases in which a person has been suddenly killed by a blow upon the upper part of the abdomen or on the pit of the stomach, which is supposed to operate by producing a fatal impression on the cardiac plexus. Whether this be or be not the true explanation, the fact itself is undisputed; it is certain that a person may die from so simple a cause without any appearance being produced, externally or internally, to account for death. On the skin, there may be some marks of abrasion or slight discoloration; but, as it has been elsewhere stated, these are neither constant nor necessary accompaniments of a blow. Convictions for manslaughter have taken place when death has been produced under these circumstances."[1]

In confirmation of these remarks, Dr. Taylor refers to a case reported by Mr. Wood, of Bury, Lancashire, in vol. xliv., p. 213, of the Medical Gazette. We have copied the general particulars of this case, that our readers may draw their own conclusions respecting it. "On the evening of July 6, 1849," writes Mr. Wood, "I was called to see David Bates, æt. 31, who had suddenly fallen in the street whilst fighting. I found him dead, and ascertained that about a quarter of an hour had elapsed since he fell. He was warm, and covered with perspiration; his face pale and cadaverous; his eyes closed, the pupils widely dilated."

Nineteen hours after death, Mr. Wood made an examination of the body, of which the following are the notes:

"*External appearance.* Escape of bloody serum from the nostrils; black ecchymosed patch on the bridge of the nose; contusion under the right ear; slight lividity on the upper part of the chest; contusion on the left elbow. On turning the body on the face, about an ounce and a half of dark grumous blood escaped from the nostrils.

"*Abdomen.* Old adhesions of the omentum in the right iliac region; arch of the colon rather dark; stomach contained some half-digested matter, and presented numerous ecchymosed points in the mucous membrane of the posterior surface at the cardiac extremity; liver rather small, and presented a slightly mottled appearance on the surface; kidneys, spleen, and pancreas healthy.

"*Thorax.* The lungs collapsed on opening the chest; were rather darkly mottled, but healthy; congested posteriorly. Old adhesions between their posterior borders and pleura on each side. Heart, healthy; contained very little blood, which was fluid. The blood generally in a fluid condition.

"*Head.* Dura mater slightly congested. *Pia mater on the surface of the brain and in the sulci between the convolutions excessively congested with dark fluid blood.*[1] No fluid in the ventricles. Substance of brain healthy, and without any lesion.

"At the inquest, three witnesses stated that Bates was intoxicated, though not so much so but that he could walk and stand unsupported by others,—that he talked a good deal and challenged his antagonist to fight; that in two or three minutes, the combatants being within half a yard of each other, Bates received a *left-handed blow, but apparently not a severe one, in the pit of the stomach;* that he fell on his face, according to the first witness, within half a minute; according to the second witness, in a moment or two; according to the third witness, instantly, dead. The first two witnesses also swore that, in their opinion, he moved his arms in a fighting attitude after being struck, and before he fell; as they thought, with an intention of continuing the fight. The third witness, however, swore that there was no action of this kind. On raising him from the ground, which was done immediately by the witnesses, a few drops of blood escaped from his nostrils, but he was dead; and all the witnesses agreed that no indication of life was observed in him after he fell. On being asked to give my opinion as to the cause of death, I stated that inasmuch as the post-mortem appearances did not furnish any other explanation, I unhesitatingly attributed it to concussion of the solar plexus, occasioned by the blow, which, according to the evidence of the witnesses, Bates had received in the epigastrium." Mr. Wood further states, that Mr. P., a medical gentleman associated with Mr. Wood in making the post-mortem examination, who also heard the general evidence, stated: "The condition of the membranes of the brain proved a great amount of excitement, and that this alone might have been the cause of death." The jury, having heard conflicting medical opinions, gave the benefit of the difference of opinion to the prisoner, and returned as their verdict, that Bates died from over-excitement. Mr. Wood adds: "The opinion expressed by Mr. P. appears to me inconsistent with all medical experience. I think all experienced pathologists admit that, in cases where sudden death from violence or accident occurs to an intoxicated person, it is usual to find the pia mater turgid with dark fluid blood, as was observed in this case. This at once disposes of the only appearance existing in the body on which Mr. P. could ground the opinion he expressed. There was no evidence adduced of any extraordinary excitement in Bates previous to fighting; he was drunk and quarrelsome, but showed no symptoms of oppression of the brain. He fell immediately after receiving a blow in the

[1] Medical Jurisprudence, p. 317; 1880.

[1] The italics are ours throughout.

epigastrium; and the manner of his death, that is, the instant extinction of life, does not accord with our experience of death occasioned by any form of apoplexy, an attack of which coincident with the blow, though quite within the range of possibility, might fairly be considered very remarkable. I regard the case as an unequivocal instance of death from a blow on the epigastrium."

Before expressing any opinion on the observations of Dr. Taylor, or upon the latter case and Mr. Wood's remark upon it, attention must first be drawn to the following extract from a prize-essay "On Wounds and Injuries of the Abdomen," by Mr. Alfred Poland, to whom the author is greatly indebted for the privilege of having been allowed to make use of this valuable manuscript:

"The epigastric and upper part of the umbilical regions contain such numerous and such vital structures, and above all, the solar plexus and its numerous branches, of such high organic importance, covered in by soft parietes little capable of resisting and transmitting external shocks, that it is not to be wondered at that death should be an immediate result of a blow in these regions.

"On inspection of such cases, no appreciable morbid changes can be detected, not even a trace of ecchymosis about the parts.

"A blow on the pit of the stomach—a hit in the wind, as it is called—does not act so much on the diaphragm as it does upon the nerves: occasionally, though not always, there is intense pain; but sometimes the shock is so severe as at once to arrest the action of the heart, and the man is killed as it were with a blow even of a trifling kind. Sir A. Cooper used to state a case which came to his knowledge, though he was not an eye-witness to the occurrence. Two men were working near the East India House, one of whom had a heavy load which he was wheeling along; his comrade said to him, "That is too much for you; stand aside, and let me—a better man—take it." He accompanied this with a slight blow on the scrobiculus cordis, and the man immediately let the barrow fall from his arms. He felt a severe shock; the sudden impulse made so strong an impression on the heart's action as to stop it, and, without complaining of pain, the man died on the spot. On examination, no lesion was discovered. In a case of manslaughter tried at the Central Criminal Court in August, 1841, death had been caused in this way during a pugilistic combat. The man received a blow on the stomach, and fell dead. As there were no marks of external injury, the surgeon thought the man had died of apoplexy. In the latter of these cases there is no detail of the post-mortem examination to enable us to arrive at, a satisfactory conclusion. Another case, somewhat more conclusive, but complicated with pregnancy, occurred in March, 1835, and was the subject of a trial on the Norfolk Circuit, at Cambridge. John Bond was indicted for the murder of his wife by beating her with a codfish. The prisoner, who was intoxicated, desired his wife to cook the fish, which weighed about six pounds. She refused, because it was not a seasonable hour, and there was no fire. He seized the fish, and then beat her over the abdomen for some minutes with extreme violence. She died in a short time afterwards, and on a post-mortem examination the marks of many bruises were found on the body. The deceased was in the last month of pregnancy, and, in the opinion of the practitioner, her death was occasioned through the shock imparted to the system by the violence of the prisoner."[1]

The cases related by Mr. Poland to illustrate the theory generally received as to the nature of these accidents are only three in number. No one acquainted with Mr. Poland's industry can suppose that he would have overlooked records of such a class of interesting cases, had there been many reported; and all who are acquainted with the rich stores of information contained within the case-books and museum of Guy's Hospital, as well as the immense practical experience afforded, in the course of years, in its wards, will feel satisfied that had such accidents, illustrating the theory advocated heretofore, been of even occasional occurrence, Mr. Poland would have had opportunities himself of recording several such facts. The case related by Sir A. Cooper proves nothing in illustration of the theory: the blow could not have been of a severe character; but had it been so, it does not follow that the blow, independent of existing disease, occasioned death. It is stated that "the sudden impulse made so strong an impression on the heart's action as to stop it, and, without complaining of pain, the man died on the spot." This statement, it appears to the author, should be received with some degree of caution; for it is doubtful whether the poor fellow was seen by any medical man until some time after death; and we would ask whether death may not equally be attributed to disease of the heart, and that the overexertion of wheeling a barrow too heavy for the physical powers of the man immediately produced that death? Such an exertion would be more likely to excite undue action of the heart, and faintness, than the blow given by the companion. The particulars of the case are by no means satisfactory. Nothing certain can be deduced from the short note relative to the post-mortem examination. We are well aware that in such examinations, in past years, exact pathological conditions were not appreciated as they are now, and that many times deaths were apt to be attributed to accidents or insufficient causes, which in our days would be demonstrated to depend on actual disease.

In the second case there is nothing to justify an inference that the blow caused death; and the cause of death, as described by the medical man who saw the case, in

[1] "On Wounds and Injuries of the Abdomen," prize essay, by Alfred Poland, Esq.

no way confirms such inference. Men engaged in pugilistic encounters may possibly die from exhaustion; and death in such instances may more reasonably be attributed to a *series* of blows, and the exhaustion produced by the exertion entailed by fighting, than ascribed to *one* blow unattended by organic lesion.

The last case mentioned by Mr. Poland does not at all bear on this subject. Many bruises were found on the body. Many blows received from any heavy weapon or instrument, by a person in an advanced state of pregnancy, might readily produce such an amount of exhaustion as to be followed by death in a very short period; but neither this case nor the two preceding appear to the author to sufficiently bear on the point, that a blow on the abdomen or epigastrium will produce *sudden* death, without the existence of some severe organic lesion to be found on post-mortem examination.

In Sir A. Cooper's case, the evidence of the amount of violence is unsatisfactory; the minutes of the post-mortem examination are wanting: Sir A. Cooper himself did not see the case; the evidence on his part is second-hand, and would not be admissible in a court of justice, nor should it be admissible in a scientific inquiry.

In the second case, the exhaustion from fighting must be considered to have had a large share in hastening death, and therefore the latter cannot be attributed to one blow: but if so, there is no proof that organic lesion of the abdominal viscera did not exist.

The third case requires no recapitulation; it cannot even be classed among the list of *sudden* deaths, as the woman is said to have "died in a short time after" she received the injuries.

With respect to the evidence adduced in favor of sudden death in Mr. Wood's case, it must be allowed that such evidence is entitled to great consideration; but there are circumstances in this case which should be weighed carefully, for no satisfactory conclusions can be arrived at from the report of one solitary example. In the first place, the man had been fighting some minutes; the perspiration on the forehead proved much exertion, this exertion supervening on a state of intoxication: the bruises on the body proved that the man had been "*punished*" previous to the blow on the epigastrium, which, in addition to the exertion of fighting, and the state of intoxication, formed three elements in favor of physical exhaustion. Then the results of the post-mortem examination of the head rather strengthen the supposition that the condition of the pia mater, his previously intoxicated condition, the various blows received in fighting, and the physical exhaustion from the mere exertion of fighting in an inebriated state, with a consequently excited brain, all combined to produce death. The state of the stomach rather indicated the effects of alcohol. In death from alcoholic drinks, Dr. Taylor states that "the brain is found congested, and in some instances there is effusion of blood;"[1] and it will certainly be admitted that in a state of inebriety, violent physical exertion entailed by a pugilistic encounter would greatly add to an already congested condition of the brain, and at the same time produce more rapid exhaustion of the vital powers than would be the case in a condition free from the noxious effects of spirits.

Still, it is due to Mr. Wood to state, that the case related by him comes near to a fair illustration of the statement and belief, that sudden death is produced by a blow on the epigastrium without evidence of organic lesion; though the author himself is nevertheless somewhat skeptical on the point that death can occur without any organic mischief resulting from the blow at the time. He has seen nothing to justify any other conclusion. After more than thirty years' experience of vast numbers of accidents admitted into St. George's Hospital, after ample opportunities of examining in the dead-house a very considerable variety of cases, after reference to all the post-mortem note-books accumulated for many years, and after inquiry among many trustworthy observers, he is unable to arrive at any other conclusion; and though he may have erred in this conclusion in the abstract, there can be no doubt that, as a general rule, *sudden* death attributable to a blow on the stomach or epigastrium must be a rare occurrence; and that medical men should be extremely guarded in ever offering an opinion as to the cause of death in such supposed injuries, without satisfying themselves, *by most careful and minute post-mortem investigation*, that no violence has been done to the viscera, either abdominal or thoracic.

But a very slight blow, without immediate evidence of internal mischief, may be followed by very severe and alarming symptoms.

The following case is a well-marked instance of such an occurrence: An old gentleman received a slight blow on the abdomen, accidentally, when turning in bed. He thought but little of the circumstance at the time, but a few days afterwards complained of pain on the right side of the umbilicus, accompanied by tenderness on pressure; with these symptoms commenced a sluggishness of the bowels; a few days subsequently, the pain having increased, a well-marked swelling was detected at the part to which pain was referred; and

[1] Taylor's Medical Jurisprudence, 217, 1880.

with this swelling entire stoppage of the bowels was established. In consultation with Dr. Ormerod and Mr. Wildbore, of Brighton, the author saw the patient a fortnight after all action from the bowels had ceased. He had been most carefully watched by Mr. Wildbore, who had withheld all solid food, and allowed nothing but fluid nourishment. Leeches had been applied, and constant fomentations to the abdomen. The patient had taken small doses of blue pill, at intervals, for several days. The tongue was moist and rather white; the pulse quiet, skin cool, no vomiting or nausea had occurred. To the right of the umbilicus, there was a distinct deepseated mass, conveying to the touch the impression of a portion of bowel matted together, and thickened by deposit of fibrin. Gentle pressure could be now borne better than a few days previously, but still produced some pain. On pressing the part alluded to, a sensation was conveyed to the hand as if flatus was moved by the pressure, and was heard apparently passing through a narrowed channel. Beyond these symptoms there did not appear to be anything really urgent; for although the bowels had not acted for a fortnight, they were not distended; in consequence, no doubt, of the very judicious treatment that had been pursued since symptoms of constipation had set in. Examination of the rectum proved the lower bowel to be empty. It was now decided that the small doses of blue pill taken twice a day should be continued; that epithems should be constantly applied to the abdomen; enemata be used occasionally, and solid food be strictly avoided. The patient had within the last few days been unable to retain injections.

The pain, tenderness, and swelling gradually subsided. A few days subsequently, the patient was moved from Brighton to Richmond, and bore the journey without any suffering.

On the twenty-eighth day of the constipation, he was again seen by the author, in consultation with Mr. Hills of Richmond. The patient was quite cheerful, his tongue clean, appetite good, and pulse quiet. The abdomen was not distended, pain had subsided, and the thickening about the right of the umbilicus had almost entirely disappeared. On examination of the bowel per anum, two or three small portions of feculent matter were felt. Mr. Hills had observed the day previous that a very small thin portion of fæces, about the thickness of a clay-pipe stem, had come away after the administration of an enema. In consequence of the feculent masses felt in the rectum, it was decided at once to inject a large quantity of warm water into the bowel. As soon as this had been done, the patient was requested to sit on the close-stool, and in a short time afterwards passed some two ounces of fæces, with the water just administered. The latter was now quite tinged with feculent matter,—the first occasion on which this condition had been observed since the constipation had set in. He expressed intense mental relief at the improved features of his case, and from that day recovery rapidly took place. He lived several years after his recovery, and died from the effects of some cerebral mischief.

A boy was admitted into St. George's Hospital late one evening. He complained of great pain over the lower part of the abdomen, but no clear statement of symptoms could be obtained from him. The house surgeon, concluding that the bladder might not have been emptied, passed a catheter and drew off a small quantity of urine. When seen by the author the following morning, the boy's face was indicative of suffering; the brow contracted, the pulse quick and sharp. The muscles of the abdomen were resistant and hard and contracted; slight pressure produced considerable pain over the lower portion of the abdomen, especially towards the right side. There was evidently peritoneal inflammation, from some cause. After some questioning, the lad confessed to having been kicked on the abdomen by a boy, while at play, the afternoon previous to admission, and that much pain was experienced after the kick. The lad was averse to mention the circumstance when he got home, but the pain became so severe the following day, that he was kept in bed by his parents, and lastly brought to the hospital. Leeches were applied to the abdomen, followed by constant fomentations, and he was ordered small doses of calomel and chalk every four hours. The next day the pain was less, but the pulse quick and tongue white and rather dry. The leeches were repeated, and the calomel continued. He steadily improved under treatment, and in a few days was convalescent. He soon left the hospital, recovered.

These cases of injuries to the abdomen followed by inflammatory peritoneal action are satisfactory instances of favorable termination.

The following case illustrates the more severe effects of peritonitis after an injury. A woman was admitted into St. George's Hospital in 1859, under the care of Mr. Johnson. She had been kicked on the abdomen by her husband, on the lower part of the left side. The kick was followed by excessive pain and general peritonitis. There was great and constant difficulty in procuring action of the bowels. The symptoms were treated by the application of leeches, fomentations, and the internal administration of mercury; but the tenderness and distension of the abdomen, constipation, and difficulty in passing motions, continued for some six months. The patient was greatly reduced, and when she left the hospital there was much distension of the abdomen, general pain on pressure, and an inability to move about with any degree of activity. The diagnosis was, that the bowels had become matted together to a great extent by adhesion of their peritoneal surface.

These cases prove that we may have to contend with severe symptoms produced by a comparatively trifling injury, and that we may find but slight ultimate mischief remaining subsequent to most alarming conditions.

Additional cases might be produced to illustrate these observations, but the relation of a greater number would not more clearly explain the practical results of such injuries; suffice it to say, that the slightest blow on the soft walls of the abdomen must always be considered with care, and treated with due caution; but that we must not look with despair on what may at

first appear, from the severity of the symptoms, a most formidable injury.

Let us inquire what are the pathological conditions and consequences of a blow or other injury on the abdomen. External to the peritoneum, we may find—

1. Rupture of muscle.

2. Contusion of the soft tissues, with extravasation of blood.

3. Without the former, and without external wound, rupture of the peritoneum, and consequent extravasation of blood into the cavity of the abdomen.

1. Rupture of muscle is not often detected as a result of external violence to the abdominal wall, unless the accident prove fatal. Any direct blow may rupture the fibres of a muscle, without producing other injury; and the abdominal muscles are not exempt from this liability. The author was consulted by a gentleman suffering from an apparent rupture of the inner fibres of the recti muscles, about midway between the umbilicus and pubes. The injury was the result of a book falling directly on the abdomen, one corner striking the part affected. There were no severe symptoms immediately subsequent to the blow, but, after recovering from the first bruise, there remained an inability to perform many of the movements of the body, especially those in which the actions of the abdominal recti muscles are much called into play. In the recumbent posture on the back, the patient was unable to raise himself, nor could he do so without turning on one side—and with care only could he move; walking to any extent was followed by discomfort, and even pain in the region injured. The local conditions presented an evident separation, or want of muscular fibres, to the extent of about one inch and a half in diameter. The patient had suffered general inconvenience in movement, rather than any constitutional disturbance; and at the termination of twelve months after the injury, appeared little better able to take active exercise than he could a few weeks after the blow. It was not considered advisable to recommend more than caution in exercise, and a support to the abdomen, so as to restrict extension of the body, either sudden or beyond the upright position.

As the result of tetanic spasm, we have witnessed rupture of the broad muscles of the abdominal wall.

Mr. Poland has favored the author with notes of two cases, in persons of advanced life, in both of which rupture of the rectus took place from the patients falling against their iron bedsteads in the wards of the hospital. In each instance, the patient had been suffering from severe illness; one from the effects of fever, the other from disease of the urinary organs, and both were at the time greatly reduced in strength.

Legouest reports the case of a soldier, aged twenty-seven, who, while performing some gymnastic exercises, was attacked with severe pain in the abdomen, which increasing and being accompanied by swelling, he was taken to the Hospital of Val de Grâce. A little above the pubes, a hard, well-defined tumor was observed, not increased by coughing, and which followed the course of the right rectus, increasing in breadth towards the umbilicus. At the termination of a week only slight hardness remained. The case terminated favorably, with rest, regimen, and cold applications.[1]

The symptoms of ruptured rectus muscles may be judged of from the foregoing cases: pain, sudden in character, most probably attended by swelling, the result of effused blood, and probably indicated by a dent in, or by a marked separation of the torn ends, of the muscle; pain, increased on motion, even to such an extent that movements of the body may be almost impossible for a time.

The treatment of rupture of any abdominal muscle, when such is suspected to exist, must chiefly consist in rest, and attention to position, so as to relax the injured muscle. The results are generally far from satisfactory, after the patient has recovered from the immediate effects of the accident; in all probability much weakness will be experienced in movements, at the injured part; and pain will most frequently persist, as a lasting evidence of permanently damaged tissue.

Another evil is very apt to follow upon the rupture of an abdominal muscle, however slight the injury may be, viz., that a hernia may present itself at the point of separation of the muscular fibres; and in most cases such a consequence may be anticipated. The coverings of such a hernia would be devoid of muscular fibres, and the contents would be little liable to strangulation, from the fact that the sac is devoid of a constricted neck. A large pad, with a bandage or truss, will be necessary in such cases for life.

We have not been able to satisfy ourselves that there is any foundation for a suggestion of Virchow, viz., that abscesses of the abdominal wall are frequently dependent for their cause on ruptured muscle.

Contusion of the external soft parts of the abdomen, with extravasation of blood into the cellular tissue, may be extensive; and will generally be indicated, more particularly a few days after the injury, by the usual ugly-looking patches under the skin, of blackish-red color, which subsequently shade off into blue and green, and roughly mark out the extent to which blood has percolated into the surrounding structures. Associated generally with such extravasa-

[1] Gazette des Hôpitaux, 1860, No. 76.

tions, there will be indications of bruised muscle to some extent; the patient will complain of pain in movements; or even while resting quietly in bed, will experience a soreness, or discomfort in respiration. There need not be much cause for apprehension under such circumstances, provided no indications be present of *peritoneal* injury.

When secondary inconveniences arise in cases of contusion of the soft tissues, they occur mostly in those instances in which *large* quantities of blood have been extravasated. Blood does not *then* become readily absorbed; and suppuration and abscess may be the result. The former will often become extensive, or the latter may form in very large collections of matter; and either may be very tedious in its progress towards reparation. The progress, however, will be slow or rapid, for good or for evil, according to the state of the patient's health and age. In an unhealthy condition of body, suppurative inflammation will generally be attended by much constitutional suffering; the integuments become inflamed, and often slough; or matter burrows in various directions, and requires constant watching, and early and ample exit: all which may, sooner or later, terminate in the patient's death, without having produced visceral complication. In old age, the skin is more apt to slough, or ulcerate if slightly bruised, and if undermined by much extravasated blood, the injury may rapidly prove fatal.

The *quantity* of the blood extravasated, quite as much as the direct *injury* to the soft parts, must weigh in the balance which determines the formation of an adverse or favorable opinion regarding the patient's future. Given the amount of the extravasation, we may almost foretell the progress of the case.

But a direct bruise may be followed by a slough of the tissues. This result, as a general rule, is not a common feature in such an injury to the abdominal walls. Usually, the apparent mischief to these soft parts is not very serious. Their peculiar attachments, their relative position to each other and to the viscera, render them capable of receiving pretty considerable pressure, without offering much resistance, and they may thus yield to and avoid the effects of compression, which would otherwise be sufficient to destroy their vitality at once, or materially interfere with it subsequently.

It is not common to witness extensive or serious contusion of the muscles and external soft tissues of the abdomen alone, short of more serious complications involving some of the viscera. So that our attention need not at present be directed to such contingencies, as the lesser evil would succumb, both in symptoms and in treatment, to the greater.

The treatment of bruises with extravasated blood in the walls of the abdomen is very simple, and should be similar in all essentials to the treatment of severe bruises of other portions of the trunk or limbs. The surgeon should ascertain, without delay, that the patient can pass water readily, and that there is no tinge of blood in the urine. The presence of blood generally indicates deepseated extravasation and visceral injury.

Rest should be enforced in the recumbent posture, or, if the bruise be very severe, or the extravasation extensive, strict confinement to bed should be enjoined; fomentations should be applied constantly to the part, to relieve pain, and they much aid to soothe the soreness and lessen the stiffness and discomfort of the bruised tissues; the diet should be regulated according to the patient's powers and constitutional state.

In extravasations of blood from contusion of the parietes, our watchfulness should be constant whenever the extravasation is so great in amount and of such an extent as to occasion a prospect of suppuration. The circumstance of suppuration following upon such extravasations will be indicated at first by some, more or less, constitutional disturbance: slight blush commencing on the surface of the skin over the injured part; the swelling increasing in extent; the inflamed skin becoming shiny and tender to the touch. Should such evidences of commencing suppuration manifest themselves, the fomentations should be changed for poultices or lint and warm water under oiled silk. As the local mischief increases, the constitutional disturbance becomes aggravated; and unless the symptoms are relieved by the exit of the matter collected, they may become very alarming in character. The earliest opportunity to give escape to matter must be sought by the surgeon. A free incision, under circumstances indicated by the above severe symptoms, is soon followed by considerable local relief, and by a marked amelioration in the condition of the patient.

And now the treatment should be conducted on the same principles as in similar injuries of other parts. Especial care should be taken to prevent matter burrowing deeply, for the want of ready external outlets; and any reluctance in the wounds to heal should be suspiciously watched, and care taken that if any sinuses exist or ensue, they be laid open to the extreme extent of practicability and safety.

Abscess, the result of extravasated blood, following contusion of the abdomen, may prove a serious as well as a tedious matter, when pus collects and burrows in and about the region of the pelvis; nor can the sur-

geon be too circumspect or too energetic in his efforts to give an early and ample vent to purulent fluid, whenever a suspicion crosses his mind that matter is lodged anywhere in the neighborhood of the original injury, and within reach of the knife. Months of suffering may result from any want of early care or prompt determination in the treatment of such a case; and it is no uncommon result, that a patient sinks after a long period of pain and suppuration, exhausted by the profuse drain on the system caused by the secretion of numerous and tortuous sinuses.

When suppuration has once commenced, and a free outlet is established, the patient should be supported by generous diet and a liberal allowance of stimulants. Frequently the drain on the system, when such accidents give rise to suppuration, is so considerable in amount that very large quantities of stimulating fluids may not only be taken with impunity, but are essential to the maintenance of life and to insure recovery.

Our next point for consideration is, the probability and the effects of rupture of the parietal peritoneum, from a blow or external violence, without injury to the abdominal viscera. The question which may naturally be asked, is, whether such an injury can occur without the complication of visceral mischief? Experience answers that it is just possible occasionally; but that in the majority of accidents, in which violence is applied to any portion of the abdominal region, such a result is the exception to the rule. In most instances, the symptoms which present themselves barely justify a certain diagnosis, and in very few instances a difference in treatment from that necessary for injured viscera. That the peritoneum will not yield to sudden stretching as readily as some of the tissues which lie subjacent to it, is well illustrated by the fact, that rupture of the peritoneal covering of the uterus has taken place, while that viscus has remained entire: also, by the fact often observed in cases of enormous and rapid distension of the large gut, when it has been suddenly blocked by a twist, a tumor, or other mechanical obstruction, in which instances we have frequently found rents in the peritoneal coat alone, without corresponding rupture of the remaining coats of the bowel.

The following interesting case would rather fall into the category of rupture of the peritoneum, with subsequent and severe hemorrhage. The author is indebted to his friend Sir R. Martin for the particulars. Two men were run away with in a gig, and one of them —healthy, and about twenty-five years of age —was thrown out with great violence, and fell from a height of many feet on a quarter-staff, which he had retained in his grasp—the one end of the staff having become fixed in the ground, while the other received the falling man upon his epigastric region. It was represented that the man was at once rendered insensible, and remained so for about an hour; soon after which he was seen in bed by Sir R. Martin. "The countenance and general appearance had all the characters of the most fatal collapse of remittent fever, with the addition of urgent terror. There was the concentrated epigastric anguish, and the body was fixed and immovable; the abdomen being enormously tumid and hard as a barrel, the epigastric region intolerant of the weight even of the sheet. The pulse was not to be counted, and the skin was cold and damp. I considered the symptoms referable to both epigastric shock and hemorrhage. The man was ordered diffusible stimuli, with small doses of calomel and opium, which were continued until the system was brought gently under mercurial influence. The patient recovered steadily and without accident." Sir R. Martin's remarks at the conclusion of the case are worthy of notice: "We can but conjecture," he says, "at the nature and extent of the injury in this case. My own view at the time was, that rupture of the peritoneum, with hemorrhage, occurred; certainly, I have seen men killed by blows, on the abdomen, of less violence than took place here. The anguish of both mind and body was greater than I remember ever to have seen, either in the collapse of remittent fever, or from wounds or accidents.

"A young officer of dragoons, who was shot in a duel, the ball passing right through the liver and spleen, suffered much anguish during two-and-thirty hours that he lived; but his sufferings were nothing as compared to those in the case above described. Indeed, I have never witnessed anything like them in severity, the patient recovering from the injury."

It may, however, be objected that rupture of the peritoneum by sudden force can rarely, very rarely, occur without some laceration of the part which the injured membrane covered. And this no doubt is the fact in very many instances; but as the consideration of ruptured viscera will form a subsequent portion of this essay, the complications of visceral injury, in connection with simple rupture of the peritoneum, need no further mention here.

In the Museum of St. George's Hospital is a preparation[1] in which may be seen a laceration of the peritoneum covering the mesentery, the latter also being implicated in the laceration to the extent of about an inch; there are also to be seen several small accumulations of extravasated blood around the lacerated part. The injury occurred in a man who was kicked on an inguinal hernia; the protruded intestine was also ruptured at a point distant from the lacerated peritoneum and mesentery.

Our diagnosis of the injuries already considered will depend on symptoms which, in some cases, will be immediate upon the injuries; and in others will not be evident

[1] Series ix., No. 93.

until some time has elapsed. A blow upon the abdomen, though followed by much faintness, need not be necessarily otherwise than harmless in its effects; and it may be pronounced to be harmless, if the faintness be not lasting, nor followed by vomiting, or pain, or great anxiety, with disinclination to movement.

Provided there be no visceral complication in any instance of rupture of the parietal or visceral layers of the peritoneum, the *first* and *chief* danger to be apprehended from such an injury is hemorrhage. If the rupture of the peritoneum be confined to any portion attached to the abdominal wall or diaphragm, the *probability* is that there will not be hemorrhage to any alarming extent. But if the rent occur in a portion attached to a pregnant uterus, to the omentum, or to the mesentery, the probability is that hemorrhage will be excessive, and it may prove fatal. Under these circumstances, there will be general blanching of the surface of the body, a cold clammy skin, anxiety of countenance, constant yawning, sensations of great distress and sinking, rapid pulse, and great restlessness in bed. In this latter respect there is a most marked difference in a patient suffering from ruptured viscera. He lies in a constrained, quiet posture, usually on his back; the muscles of his abdomen are tensely contracted. The patient with ruptured intestine complains of severe continued pain, always accompanied by vomiting, which is persistent and constant, and which nothing relieves; but with rupture of the peritoneum alone, followed by excessive hemorrhage, whatever the amount of pain, vomiting may and will generally be entirely absent; and in the absence of pain, the patient's anxiety is solely referred to the extreme collapse, and he often expresses himself to be dying.

The course of such a case is run more rapidly than that of one with ruptured intestines without hemorrhage. A few hours may terminate life, before any secondary action has had time to commence. It is the extent of extravasation, rather than the extent of laceration, which settles the rapidity of the case;—it is *that* alone, we may almost say, if the viscera be not ruptured, which calls for our utmost care, and aggravates our anxiety. Short of hemorrhage, and short of ruptured intestine, a laceration of the peritoneum *need* not alone be fatal —probably *will* not be fatal. The conditions generally found after death, when hemorrhage has been the fatal cause, are either rupture of the mesenteric vessels, or of the vena cava, or other large veins or arteries. The rupture of the larger vessels seldom is the result of a blow, but rather that of heavy weights passing over the body. The portal vein has been found ruptured previous to entering the transverse fissure of the liver, and without laceration of this viscus.

In the treatment of such injuries, no general law can be laid down, no canon can dictate our practice. Passing over those cases in which excessive hemorrhage rapidly destroys life, and which admit of no beneficial or mitigatory treatment, let us look at such as may require the surgeon's care, and may be successfully managed. The cases which will demand, and will repay, the most careful watching—perhaps much active and assiduous attention—are those in which the injury is followed by peritonitis, either of a chronic or of an acute character. Such cases must be constantly, frequently, and most carefully watched during the early days after the accident; for it may well be laid down as a maxim, the truth of which we have already illustrated, that the most trifling blow on the abdomen may be followed by symptoms sufficiently serious and alarming, and require our utmost skill and attention.

In most cases, should symptoms of peritonitis supervene, we may safely resort to the free application of leeches to the abdomen, over the part chiefly in pain; and these should be followed by large and hot fomentations of moist flannels, or flannel-bags of bran or camomile wrung out of hot water, or large linseed-meal and bran poultices. Sometimes the relief to pain and the personal and local comfort afforded by leeches and subsequent warm applications, is most marked in these cases, and often highly satisfactory to the patient and beneficial in treatment. Opium, under the circumstances of peritonitis supervening, is the sheet-anchor of the vessel riding in a gale of wind. Opium should be given freely, fully, and frequently. The index to its limit is the effect on the system. We should only allow it to be diminished or withdrawn when narcotism is indicated by the manner of the patient, or the effect observed on the irides, or a marked abatement in the severity of the local symptoms, for the relief of which it was ordered. Calomel, in our opinion, should also be combined with opium, in these peritoneal affections, though only in small doses often repeated. It should be withheld on the first evidence of its specific action on the mouth and tongue.

Purgation should be avoided as a provocative of inflammation in these, as in all inflammatory affections within the region of the abdomen resulting from injury. If rest be desirable to the broken limb, equally is quiescence necessary to the recovery of the patient with lacerated tissues within the cavity of the abdomen; and any purgative may be looked upon as mischievous in such injuries. To allow an inflamed eye or any

injured organ to recover, we advocate rest, that nature may exercise her share, not a small one, in the restoration of each to health. It is the well-judging surgeon who, taking a hint from nature's teaching, leaves to rest and quietude that which by active treatment might be seriously injured. And yet purgatives of an irritating character are sometimes recklessly advocated in the early stages of such accidents; a treatment which cannot be too strongly condemned, and a practice which only appears adapted to accelerate a fatal termination. If constipation supervenes, the mercurial treatment should be steadily persevered in, short of salivation to the slightest degree; and trust should be placed in the natural action of the intestine, subsequent to the reduction of inflammation, rather than in any efforts made to hasten the action by other measures, with an expectation that purgatives can lessen the local mischief.

Rupture of the diaphragm is not a very common injury, and when it does occur is usually the result of much external violence.

In such a case, there is generally found to be some serious visceral mischief associated with the laceration of the muscle. But a rupture of the diaphragm may take place without lesion of the adjacent viscera; and in such an instance hemorrhage will in all probability be small in quantity.

A wound of the diaphragm may be readily produced; the muscle has been often transfixed by a knife, or bayonet, or other sharp-pointed weapon thrust into the lower portion of the thorax, or through the upper portion of the abdominal wall. A wound of this muscle produced by a penetrating instrument will, most probably, be complicated with wounds of some of the adjacent viscera; and in such a case hemorrhage will generally be rather severe.

A rupture or wound of the diaphragm, if not complicated with visceral injury, and if not considerable in extent, is by no means necessarily, of itself, immediately or ultimately fatal. Even with a large laceration of this muscle a person may live for some months. The second case recorded at page 898 is a well-marked instance of a severe laceration of the diaphragm: in this case the patient survived eleven weeks, although the laceration was complicated with rupture of the spleen.

There is no limitation to the part of the diaphragm which may be the seat of a *wound*, but in the greater number of cases of *laceration* it has been observed that the injury has been confined to the left side. Devergie has confirmed this observation, which is supported by the case on p. 898, and by the following instances:

Thomas A., aged twenty, was admitted into St. Mary's Hospital, "suffering from pneumothorax and diaphragmatic hernia," of which he died about thirty-two hours after admission. "The opening in the diaphragm was in the left portion of the tendon, near its posterior part, and was large enough to admit the hand."[1]

E. L., aged forty, was admitted into Guy's Hospital, having fallen from a great height on the deck of a vessel. He died about three months after the accident. An opening was discovered in the diaphragm a little to the left of the œsophageal opening, about two and a half inches in extent.[2]

The symptoms of laceration of the diaphragm, we may conclude, will be generally of an obscure character; and it will very much depend upon the manner in which the accident occurred, whether sufficient symptoms will be referred directly to the seat of injury to enable the surgeon to arrive at a correct diagnosis. If the rupture be the result of a fall from a height, or of a heavy weight having passed over the abdomen, there will be so much general bruising, or visceral laceration, that any symptoms of rupture of the diaphragm will escape detection in the more severe and urgent condition of the patient. But the muscle may be ruptured by sudden spasm or action caused by a slight fall or slip. The patient would, under such circumstances, be cognizant of an instantaneous snap or darting sensation in the part, followed by intense pain. There would also be more or less difficulty in walking; inability to use much muscular power; and most probably some disturbance or difficulty in the respiratory movements.

Thomas A. (the case already quoted) "slipped while walking in his own house; and in trying to save himself from falling gave himself a severe twist, when he felt something snap at the lower ribs on the left side, followed by great pain, to such an extent that he could hardly breathe for some minutes."

A laceration or wound of the diaphragm *per se* is not necessarily fatal. But the aperture in the muscular septum is generally productive, sooner or later, of serious results. These serious consequences arise from the escape of some of the contents of the abdomen, through the laceration, into the cavity of the thorax; such a protrusion constituting that variety of hernia termed phrenic or diaphragmatic. "A uniform effect of these ruptures when extensive," writes Dr. Alfred Taylor, "is a protrusion of the stomach into the chest, with sometimes a rupture of the coats of that organ, and extravasation of its contents."[3] But portions of the small intestine, transverse colon, omentum, and spleen have been found in the cavity of the pleura subsequent to an extensive laceration of the muscle.

[1] British Medical Journal, 1858, p. 922.

[2] Poland's Prize-Essay, p. 330; also Guy's Hospital Reports, 1838, p. 366.

[3] Medical Jurisprudence, p. 392.

The symptoms of such protrusion into the cavity of either pleura would be generally well marked. The side of the chest implicated will be somewhat prominent, and the heart will, to a corresponding extent, be pushed over in the opposite direction. On percussion the sounds may vary. If the protrusion be stomach or intestine distended with air, the resonance will be most evident; but should solid viscera have passed through the laceration, the sounds will, to a corresponding extent, be dull. No respiratory sounds will be heard, under either condition, over the part in which lie the escaped viscera. Constant vomiting will also be generally present. With the escape of portions of the viscera into the cavity of the chest, obstruction to the passage of their contents usually occurs, and the patient's life is soon sacrificed. Or death may follow an attack of pleuritis, either set up immediately by the rupture, or subsequently produced by the irritation of the foreign viscera in the cavity of the thorax.

We are silent on the subject of treatment in this accident. As long as the opening in the diaphragm exists, there is the prospect of protrusion of viscera through it, and consequent obstruction. We cannot hope to close the aperture by any measures which science or mechanical surgery would justify; and therefore, could we most accurately detect the existence of a protrusion of viscera through the aperture, it were vain to attempt its reduction with any prospect of benefit to the patient or credit to ourselves.

Contusion of the parietes of the abdomen, complicated with rupture of viscera, is a subject replete with interest, and an injury more formidable in its character, and more fatal in its results, than most of those alluded to in this essay.

In their respective order, we must consider individually rupture of the food-tube and its accessories: viz. (1) the stomach and intestines, (2) the liver and the spleen.

As the result of accidental violence, rupture of the *stomach* in a state of health is a very rare occurrence. In its results, as a rule, it may be considered as surely fatal. Rupture or rather perforation of the stomach, the result of ulcer, is not an uncommon lesion; but is one rapidly fatal, and consequent on a long-standing and troublesome affection. Such an occurrence is characterized by sudden, sometimes excessive, pain, great depression and intense anxiety, rapid pulse, and every indication of immediately approaching death. A few hours suffice to terminate the sufferings of the unfortunate victim of this disease. It would be useless, were it our province, to offer any remarks on the treatment of such a case.

The blow or compression which would in a state of repletion be sufficient to produce a large rent in the stomach, would occasion but a small opening if little food were contained in it; but however small in quantity this might be, the escape of the smallest portion into the peritoneal sac would be sufficient to originate violent inflammation, and that of a rapidly fatal character.

Under any circumstances, can we entertain a hope that rupture of the stomach may not prove rapidly fatal? It is just possible. If the laceration of the coats were confined to those portions which are attached to the omentum, above or below, extravasation of the contents might be limited in quantity, and confined to parts external to the cavity of the peritoneum; though such a condition would probably be but a temporary stay to future mischief; for the extravasation would sooner or later terminate in suppuration, and the secondary mischief set up prove equally fatal, as a rule, as when it follows at once upon the escape of the stomach-contents into the cavity of the peritoneum.

It is probable that the following case may bear the above explanation. A woman received an injury on the abdomen, followed by an indolent swelling over the left part of the epigastrium,—which swelling, suppurating, and ulcerating externally, formed a fistulous communication with the cavity of the stomach. The woman lived some months after the formation of the fistula. On the examination after death, the opening in the stomach was found towards the pyloric extremity, and was intimately adherent to the abdominal parietes.[1]

In the first number of the London Medical Review, July, 1860, is recorded a case of rupture of the stomach, in a man aged twenty-four, who fell from a ladder on some iron railings. He died about eight hours after the accident. When admitted into the Middlesex Hospital, under the care of Mr. Moore, the patient was perfectly sensible, but in a state of great prostration—pulse very small and feeble. Brandy was administered. This he took with great reluctance, and at his earnest request it was not persisted in. He stated that it increased his sufferings.

Post-mortem examination.—"The cavity of the peritoneum contained about twenty-six ounces of fluid, resembling coffee-grounds. On the anterior aspect of the stomach, just below and to the left of the pylorus, was an abrasion of the peritoneal coat two inches in length. Immediately beneath the pylorus, the anterior wall of the stomach was completely ruptured, in a horizontal direction, for the space of three inches. The mucous membrane of the stomach, just above and just below the rupture, presented two clean cuts, exposing the submucous tissue, which was intensely injected. The upper of these cuts measured three inches, the lower one, an inch and a half." Most of the ribs on the left side were fractured, and there

[1] Richerand, Physiol., tom. i., p. 282.

was rupture of the spleen. "There was a superficial abrasion of the liver, an inch long, on its inferior surface. Close to the internal abdominal ring, on the right side, was a rupture of the peritoneum, large enough to admit the thumb. There were also numerous abrasions of the peritoneal coat of the transverse colon."

Perforation of the *intestine*, that is, rupture of the intestinal coats, the result of external violence, without any external wound, is by far the most frequently formidable injury of the abdominal viscera with which the surgeon has to contend in practice. From the commencement of the duodenum to the termination of the sigmoid flexure of the colon, in any part of the whole length of the intestine, rupture of the entire wall does constantly occur from violent, sudden, or passive forces applied to the front or sides of the abdomen. We propose to consider the various forces which produce such accidents, and the various situations in which the injury may occur.

Rupture of intestine is a very common result of a kick from a horse; in very many cases admitted into St. George's Hospital with rupture of the bowel, the injury was attributable to this cause. In such cases, the aperture in the bowel is generally small; whereas more extensive lacerations are found when the injury has been caused by heavy weights passing over the body. In the latter instances, the intestine may almost be severed transversely. Every variety, from a small pin-hole perforation to an entire transverse division of the walls of intestine, may occur from a variety of forces acting on the abdominal walls; but into these points it is not necessary to enter more minutely. It may fairly be asked, whether a rupture of the intestine is to be considered a fatal accident? It can, we fear, rarely happen that recovery should take place, if the lesion be sufficient to permit the escape of fecal matter into the peritoneal cavity, and the rupture be not accompanied by an external wound. The effects of such a lesion are so formidable, that we may certainly, as a rule, pronounce all such cases to be utterly beyond the boundaries of relief and recovery.

A man was admitted into St. George's Hospital in December, 1841, having been rolled upon by a horse that fell with him. The patient complained of severe pain across the abdomen; countenance very pale; pulse very weak; not much tenderness on pressure; vomiting soon commenced after admission. The following day all the symptoms were aggravated; the pulse became very quick and small; countenance very anxious. He died thirty-four hours after admission. There were general adhesions of the peritoneum to the great omentum, and also of the convolutions of intestine to each other; the lymph being of dark grumous color. The cavity of the peritoneum contained a large quantity of bloody fluid, quite free from fecal taint. About the middle third of the jejunum, the bowel was formed into a kind of loop from adhesion to the transverse colon, and presented a very dark and congested condition; on separating the adhesions, a small rupture of the jejunum was seen; escape of the contents of the bowel had been prevented by firm adhesions, and also by a large coagulum formed in the immediate situation of, and fairly surrounding the rupture. Some portions of the intestine presented a dark appearance, as if bruised.

Such a case as the above marks the possibility of rupture of intestine without escape of fecal matter. This patient probably died as much from the effects of inflammation, set up by the bruised intestine, as from the effects of the rupture. The post-mortem appearances in this instance are a fair index of the pathological conditions generally found after similar injuries.

The immediate effects of such a lesion as rupture of the bowel from external violence are most characteristic. The pain following the blow is rapidly merged into that which is often excessive, and is apparently the result of the escape of feculent fluid into the peritoneal sac. Pain is much increased by pressure, and sometimes to such an extent that the patient cannot bear the weight of the bed-clothes. The anterior abdominal muscles become rigid and unyielding to the touch; tense, hard, and resistant to any examination by the hand; and almost convey the sensation of a board, rather than that of animal tissue, laid over the surface of the bowels. If the abdomen be uncovered, and the patient requested to draw a long breath, the action of respiration will be observed confined to the thoracic muscles: those of the abdominal wall will be still, fixed, and unmoved. The countenance rapidly assumes the most anxious and restless aspect; vomiting sets in early, and is more or less constant and distressing to the end; the fluid vomited being at first the remains of the last undigested meal, and then porraceous, and latterly dark-colored, slightly tainted by feculent smell. The tongue varies in appearance, but generally is coated and dry, and red at its edges; great thirst is often a marked symptom. A symptom spoken of as a sure indication of ruptured bowel, is early and excessive collapse; but collapse, though generally present to a great extent, will sometimes be wanting to such a degree, that if, as a symptom, it be much depended on, an incorrect conclusion might be arrived at respecting the extent of the injury.

The coachman of my friend and colleague, Dr. Fuller, was kicked on the abdomen by a horse, early in the morning. The man experienced great pain immediately after the accident, but was able to walk some little distance from the stable to his lodgings, and then up-

stairs to his bedroom, without any indication of collapse. When I saw him with Dr. Fuller, about an hour after the accident, there was no collapse, and the pulse gave very little indication of serious mischief; but the pain, the tense state of the abdominal muscles, the anxiety of countenance, and the vomiting then present, pretty surely indicated rupture of the gut. The post-mortem examination displayed a lacerated opening in the small intestine.

It may appear superfluous to speak of treatment, when we start with the conviction that rupture of bowel is necessarily fatal. But in these serious injuries, if treatment is to be of avail, it certainly appears absolutely necessary that all our efforts should be directed to the maintenance of rest in the injured part. It will be found that vomiting and costiveness are the invariable accompanying conditions of ruptured intestine. Nature's indication, as well as nature's effort, appears to be, to avoid all disturbance, and preserve strict rest of the injured part, by emptying the tube above, and arresting its action below; and the lesson she teaches us we should be ready to appreciate and enforce. Opium administered internally from the first, is one great indication marked by her teaching. We learn the advantages of opium administered in instances of bruised or inflamed intestine reduced after strangulated hernia; equally important, if not more so, is the action of this drug in cases of ruptured bowel. The dose is only to be suspended when narcotic effects are evident, but otherwise should be repeated and increased until some beneficial or specific action is observed. Leeches to the abdomen, fomentations, sinapisms, and turpentine on flannel, should be applied much in the order stated; and the leeches repeated, if requisite to relieve pain, etc. In such cases depletion cannot be had recourse to often, or carried very far, with benefit. The pulse soon begins to fail. It must ever be borne in mind with respect to treatment, that the inflammatory action is the result of local extravasation, and not of idiopathic or constitutional causes, and therefore less under the influence of general measures. It is a question how far mercury should be administered in these injuries. I believe it to be occasionally a beneficial, and therefore justifiable, therapeutic agent, but only in combination with opium; and with opium it should be administered in the early stages of the symptoms, in small and oft-repeated doses. One grain of each drug may be given every three or four hours. The repeated doses of opium will often be borne for many hours, and the patient in no way injuriously affected by it.

A few hours to three or four days will be the extremes of time that a patient may survive after the occurrence of a rupture of the bowel. Upon examination after death, marked evidences of the escape of the contents will be present: general peritonitis, the edges of the convolutions being glued together; discolored and purulent fluid confined between the folds of the intestine, and especially in the lower portion of the peritoneal cavity. According to the size of the rupture, so in a great measure will be the amount of effusion, as also the rapidity of the termination of the case; for the symptoms will be more acute, and the progress more rapid, the larger the escape of feculent fluid. The wound in the intestine will often be hidden by adhesions, and care is sometimes required to ascertain its situation. It will probably have early become adherent to the adjacent surface of the bowel, or omentum, or any neighboring viscus, and, as a consequence, before the period of death escape of the contents of the gut will have ceased. The edges of the wound are always found everted, and the mucous coat projecting, plugging up the aperture when not of a very considerable size.

In an injury such as we have now considered, what prospect has a patient of recovery?

It would be mere conjecture to suppose a case of recovery probable after escape of fecal fluid into the peritoneal sac. It only appears possible that a patient should even survive for a time, *i. e.*, beyond a few days, if the rupture were situated at the attached margin of the bowel, and the escaped feculent fluid were confined between the layers of the mesentery. In snch an exceptional case we must expect subsequent serious mischief. Abscess and chronic peritonitis, and more or less adhesion of the surfaces of the intestines and viscera, would be the chief features of the case: matter might approach the surface, and be detected in time for evacuation, before discharging into the peritoneal cavity. Such a case is not unfrequently met with after convalescence from fever, or from ulceration and perforation of intestine from other causes. Such a case would be long in recovering, and would call forth all the attention and skill that the experienced practitioner could bestow upon it. An early exit for the pus would be most important, and great care should be taken to prevent burrowing sinuses, and confinement of matter. [I will venture the suggestion that when the diagnosis is clearly made, it is the surgeon's duty to open the abdominal cavity, search for the rupture, check the hemorrhage, stitch up the rupture with catgut, sponge out the peritoneum, close the abdominal wound, and apply antiseptic compresses with a snugly fitting binder.]

Lacerations of the substance of the *liver* will be frequently met with in post-mortem

examinations of persons whose deaths have been occasioned by injuries to the abdomen; but though such lacerations are not uncommon results of accidents, the termination need not necessarily be fatal.

If the laceration be not extensive—if it be limited to the surface of the liver, merely a slight superficial crack—the patient may recover without much suffering, and without any particularly marked indication of the existence of the injury. If the laceration be at all extensive or deep, the patient soon dies from the effects of hemorrhage into the peritoneal cavity. Post-mortem examinations bring before us every condition of rupture, from the slightest rent running through the peritoneal covering, and barely tearing more than the most superficial surface of the liver, to the most complete smashing up of the organ. Only in the slighter injuries can we anticipate a favorable result. Death rapidly steps in, and appropriates the more serious.

A man, aged thirty-three, was admitted into St. George's Hospital, November 25, 1847, under the care of Mr. Cutler. The patient was blanched, and in a cold sweat. He had been shortly before kicked on the epigastrium by a horse. The man was in great pain, and excessively faint, and became rapidly more exhausted. He died an hour and a half after admission. There were marks of recent ecchymosis over the epigastrium, and in the substance of the muscles, especially on the left side. The cavity of the peritoneum contained much fluid blood. There was a very extensive laceration of the liver, nearly separating it into two portions, these being held together by nerves, vessels, and some shreds of bruised liver-tissue. There were also some lacerated spots on the posterior surface of the left lobe. The other viscera were healthy.

Rupture of the liver may occur without rupture of the peritoneal coat, and without hemorrhage into the peritoneal cavity. A man, aged twenty-five, was admitted into St. George's Hospital, May 26, 1847. He was pale, cold, and gasping for breath. He died in two hours. The wheel of a heavily-laden cart had passed over him. The peritoneum covering the upper surface of the liver appeared slightly bruised. On cutting into the upper part of the right lobe, considerable laceration of the substance was found, though the peritoneum was entire.

In this instance there was also extensive laceration of one lung, and fracture of several ribs; but irrespective of such complications, the injury to the liver might fairly be considered as one favorable to recovery; an instance of laceration of the liver unattended by hemorrhage into the peritoneal cavity.

We cannot mention any definite symptom by which, during life, a rupture of the liver may be unmistakably detected. If the rupture be slight, there is but little beyond the usual symptoms attendant upon an injury of the abdomen, not of a severe character. Greater tenderness may be experienced over the region of the liver than elsewhere; but such a symptom cannot be assumed to be positively demonstrative of laceration; for, on the one hand, the tenderness may exist after a direct blow without rupture, or, on the other hand, the liver may be lacerated from violent concussion of the organ, and there be no marked or defined local pain.

When the laceration is extensive, it may be suspected more surely than when slight, from the rapid collapse of the patient; loss of pulse, extreme faintness, pallor, and great distension of the abdomen,—all indicative of excessive internal hemorrhage.

Injuries of the abdomen productive of laceration of the liver, and attended by such hemorrhage, are perhaps the most rapidly fatal of all; and patients will expire in periods shorter or longer, proportionate to the amount of bleeding.

It would be useless to talk of treatment in such cases. Death steps in and removes the patient from suffering, often ere the question of restorative treatment can barely be entertained. But in minor lacerations every precaution requisite in the treatment of other injuries of the abdomen must be strictly observed. Absolute rest is one most essential condition to be insisted on. *The patient should not even be allowed to raise himself or be raised in bed*, if it be suspected that much blood has escaped into the cavity of the peritoneum or elsewhere. For under such circumstances, though the patient may appear to be going on well, death may occur upon the slightest exertion. If pain supervene, and the pulse indicate increased action, leeches may be applied with caution. But opium should be administered, alone, to quiet the nervous system, or combined with calomel in small doses, should peritonitis be evidently commencing. Fomentations, or large warm poultices applied over the whole of the abdomen, frequently procure considerable relief in pain, and afford great comfort to the patient under such circumstances. The treatment must, however, be guided by symptoms, and no very general law can be laid down as to its adoption.

Pain is frequently felt over the region of the injured part for some time subsequent to recovery: such pain indicates the necessity of care on the part of the patient; for secondary inflammation may be set up by any prolonged or reckless indulgence in exercise or violent exertion. *It is always impossible to estimate the amount of injury in the most favorable cases, or to calculate the amount of blood extravasated.* With judicious treatment in the early stages of the injury, the rupture of the liver may have united, and the effused blood may have commenced to disappear, but adhesions of the peritoneal surfaces about the injury probably exist to some extent; if by

too active movements on the part of the patient these adhesions become disturbed or destroyed, all previous benefit may be entirely lost, and a fatal termination be the result.

The following case indicates the extreme importance of strictly maintaining the recumbent posture after severe collapse.

A man, aged forty, was admitted into St. George's Hospital in May, 1845, under the care of Mr. Cutler. The patient was in a state of collapse, and complained of intense pain over the abdomen, which was considerably distended; some of the ribs on the right side were fractured. The pain gradually subsided, though the patient remained very exsanguine. He appeared to be gaining some strength, when he died suddenly, three days after the accident, on attempting to raise himself up to get upon the bed-pan. The cavity of the peritoneum contained a large quantity of blood. The convolutions of intestines were glued together by the fibrin of the extravasated blood, which had partially lost its color, and formed slender adhesions. There was an extensive rupture of the liver. The ruptured parts were well adapted to each other. and pretty firmly united by the fibrin of the extravasated blood.

That a rupture of the liver may unite, and that a patient need not die from the effects of such an injury, there can be no doubt: the following case is an illustration.

A man, aged thirty-eight, was admitted into St. George's Hospital, under the care of Mr. Cæsar Hawkins. The patient had fallen from a hay-rick, and struck his back against a log of wood. There was complete loss of voluntary motion and sensation in the parts below the nipples. There was considerable collapse, which continued for several hours. The urine drawn off contained a large proportion of blood. Sloughs formed upon the back, etc., and death occurred exactly three weeks after the accident. The body of the seventh cervical vertebra was broken into fragments, and the spinal cord corresponding to this vertebra was softened and diffluent. The cavity of the peritoneum contained a little bloody serum. An extensive rupture was found on the upper surface of the right lobe of the liver; this rupture, which measured five inches in length, was perfectly united, with the exception of some few points, where the peritoneal coat still remained broken; but no lymph was found on the serous membrane, which retained its polished surface. *The rupture did not extend very deeply into the organ.*[1]

Such a rupture as the above, occurring without other mischief to the body, may reasonably be considered as by no means fatal in its character, nor in this instance can the injury to the liver be looked upon as at all implicated in the cause of death.

In conclusion, from the results of the cases quoted, and for the reasons adduced, we may fairly state that the treatment of the *convalescent* is a matter of as great importance as that of the patient in the early days of an injury suspected to be laceration of the liver.

Rupture of the *gall-bladder*, or of the common duct, may occur without rupture of the liver. The symptoms are generally marked,—considerable pain in the region of the injury, excessive collapse, and great anxiety. Death is generally rapid; and post-mortem examinations have detected the escape of the bile into the cavity of the peritoneum.

Mr. Poland relates the following case. "A boy received a blow on the abdomen, followed by great pain and speedy death. There was found extravasation of bile, and rupture of the ductus communis choledochus, with lymph thrown out in the neighborhood."[1]

Dr. Fergus has recorded an interesting case of rupture of the gall-bladder, in the 31st volume of the Medico-Chirurgical Transactions. A boy, aged seventeen, fell off the shaft of a cart, the wheel of which passed over the abdomen, just below the false ribs. The boy complained of pain in the abdomen, but not of a severe character; the amount of shock was trifling. In the night following the accident, severe pain commenced in the abdomen—the countenance became anxious and the pulse small and rapid. These symptoms were actively treated, and he improved so much that on the fifth day after the receipt of the injury he was considered convalescent, and was allowed to get up. Two days subsequently, he was so far recovered, that the question of his quitting the hospital was entertained, when about noon he was suddenly seized with extreme pain and a sense of tightness in the abdomen: in an hour the pain had extended all over the abdomen, and was increased by pressure; the countenance was full of anxiety, and the pulse small and rapid; the symptoms present were those of acute peritonitis, from effusion of foreign matter in the cavity of the abdomen. Notwithstanding the most judicious treatment, the symptoms increased in severity, and the patient died on the ninth day after the first receipt of injury.

On opening the cavity of the peritoneum, an immense gush took place of a dark liquor, having precisely the color and odor of bile. The intestines were roughened from the effects of peritonitis, and shreds of lymph were floating in the dark fluid. "The liver was lacerated in the direction taken by the broad ligament, quite through its substance, and to a depth from the thin edge of two inches and a half; another laceration extended about two-thirds of the length of the convex surface in a transverse direction. The omentum was found rolled up in a mass underneath the liver, and slightly adherent to it, of a dusky dark color, and gave way under the least pressure. The neighboring portion of the transverse colon was of the same color, and nearly as fragile. The gall-bladder was ruptured above, near the junction of the hepatic with the cystic duct, at a spot in immediate relation and in contact with the mass of omentum above described;

[1] Cases of Ruptured Liver, by Mr. Johnson, Med.-Chir. Trans., vol. xxxiv.

[1] Prize Essay, by Alfred Poland.

the gall-bladder was quite empty and contracted."

The question arising from the history of this case is, whether the secondary and sudden attack of inflammation might not have been dependent on the extravasation of bile, just previous to the attack of pain —this extravasation being the result of some of the adhesions between the omentum and the gall-bladder becoming broken up by accidental causes. The case points out, in its progress and by its result, the very great importance of enforcing rest and quietude in all injuries of the abdomen, such as this boy had suffered. We may consider, that after injury to the abdomen, a patient is not safe under the period of a fortnight, even if he be entirely free from all symptoms.

The *spleen* is frequently ruptured in injuries of the abdomen. Such lacerations generally occasion considerable internal hemorrhage. The symptoms attendant on any rupture of the spleen will barely justify an opinion being hazarded whether the laceration be in the spleen or in the liver. The symptoms do not vary much in either injury; the only points which can in any degree guide our diagnosis are, the nature of the blow and the situation of the injury. If the laceration of the spleen be more than very superficial, hemorrhage will probably be more considerable than it would be in a similar extent of laceration of the liver, and death will rapidly follow.

A boy about nine years old was pushed into a gravel pit by a companion, and in falling struck his left side against the edge of a barrow. This occurred after his dinner and while on his way back to school for the afternoon. He felt much pain at the time, but not liking to complain managed to walk into the schoolroom. He then soon became very faint, and appeared so ill that he was at once sent home, but a short distance off; and was immediately seen by Mr. Halford of Hammersmith. He found the little patient very much collapsed and in much pain. In consultation with the author the boy was seen the following day. The abdomen was distended, muscles unyielding, and all the general indications of severe visceral laceration with peritonitis commencing.

These symptoms increased in severity, and the boy died a few days after. The spleen was found nearly separated into three portions, and much smashed; a large quantity of blood was extravasated in the abdominal cavity, and mixed with recently effused lymph and purulent fluid.

Though rupture of the spleen need not prove *immediately* fatal, secondary mischief may supervene and *ultimately* produce death.

A man, aged twenty-four, was admitted into St. George's Hospital under the care of Mr. Cæsar Hawkins, August 29, 1845, having fallen from a scaffold the height of about twenty feet. On admission the patient did not appear to suffer more than from a serious shake; but about three hours afterwards he became collapsed almost like death, and was scarcely conscious for a short time. He gradually recovered from this condition, and then complained of pain in the left lumbar region. During the following nine days he had repeated fainting-fits; but these disappeared subsequently, and he appeared to be gaining strength slowly. In October, he was sufficiently recovered to sit up, and he even walked one day from his bed to the fire-place in the accident-ward, a distance of about twenty feet. Subsequent to this exertion, he was again attacked with faintings, increased pain, cough, etc., and he died November 15, about eleven weeks after the accident.

The cavity of the left pleura was divided by adhesions: the upper half contained serum and flakes of lymph; the lower half was filled with sero-purulent fluid and lymph. The pleura corresponding to the latter surface was covered with a thick layer of lymph. The surface of the left lung, corresponding to the diaphragm, was adherent to the latter. A large foul abscess occupied the lower portion of this lung; and this abscess communicated with a large cavity containing pus, between the lung and the diaphragm. Corresponding to the lower surface of this cavity was a ragged opening in the diaphragm, about an inch in length, through which the abscess in the pleural cavity and lung communicated with one in the cavity of the abdomen, behind and to the left of the stomach.

The surface of the peritoneum was throughout of a black color, as if washed over with ink. There were numerous adhesions of the peritoneum. The posterior surface of the left extremity of the stomach was fastened down by adhesions, in separating which an abscess containing half a pint of pus was found; the walls of this abscess were formed by the stomach and transverse colon, the diaphragm, and the upper surface of the left kidney. The spleen was found ruptured into two portions: one, the upper portion, being surrounded by pus, and, as it were, in the abscess; while the other, the lower portion, was situated in front of the abscess. The inferior surface of the diaphragm corresponding to the abscess was lacerated from the median line to the extent of six inches to the left side.

Rupture of the *kidney* is a lesion often met with in post-mortem examinations of individuals whose deaths have been occasioned by violence. This lesion may, however, occur, independent of injury to any other viscus; and the termination may be rapidly fatal. A bruise of the kidney may occur without rupture of the surface; and subsequent inflammation, the result of the bruise, produce abscess, and other more serious mischief.

A gentleman was bruised over the left loin by a fall in hunting, and experienced severe pain in the back on arriving at home. He was very judiciously treated for some weeks after the accident, and came under the notice of the author some months subsequently. The bladder was now very irritable; and highly offen-

sive urine, mixed with pus, was constantly passed. There was every evidence of abscess of the kidney: the quantity of pus was sometimes very considerable. The health became gradually deteriorated, and death occurred about two years subsequent to the accident.

The left kidney was entirely destroyed; and in its situation was found a large irregular abscess, with its walls adherent to the surrounding soft tissues, and its cavity continuous with the ureter.

Without much more external evidence of bruise than in the previous case, very extensive laceration of the kidney may result from a blow over the lumbar region.

A boy was struck, over and rather in front of the right lumbar region, by the handle of a truck, in consequence of the truck coming in collision with a wagon. From the violence of the blow, the boy was forced against a post of a gateway. He immediately fell, and though able to rise and walk a few steps, he again fell, and was then carried to Guy's Hospital. He was in a state of extreme collapse, with some pain in the abdomen. He died within an hour and a half of the accident.

Externally there was slight ecchymosis over the extremities of the seventh and eighth ribs on the right, and the last two ribs on the left side. The cavity of the peritoneum contained a large quantity of coagulated and fluid blood. All that portion of the left kidney above the entrance of its vessels was torn from the lower portion, and was separated from the natural surrounding attachments. The lower portion was not disturbed in its position. There was some ecchymosis on the surface of the liver, opposite to that on the chest.[1]

In proportion to the severity of the injury must we anticipate different features in the symptoms which accompany laceration of the kidney. Generally there will be excessive collapse, attended by early vomiting; pain referred to the course of the ureter, as well as to the lumbar region; retraction of the testicle and frequently great pain referred to the testicle itself and to the lower part of the abdomen; and numbness of the upper part of the thigh. All these symptoms will probably increase in severity, should the patient survive, and infiltration of urine occur. The urine drawn off will be high-colored and scanty, and will generally be much tinged with blood, often containing a very large proportion of blood. There will frequently be observed, passed through the catheter, long, thin coagula, casts of the ureter, taken by the blood, as it coagulates in its passage to the bladder.

Should the rupture of the kidney be confined to the anterior surface, and any escape of urine occur through the lacerated part, acute peritonitis will rapidly follow. If the rupture be confined to the posterior surface, and urine be extravasated into the subserous cellular tissue, though the symptoms may, in the first instance, be less indicative of peritonitis than in the former condition, suppurative inflammation will soon be marked by its characteristic symptoms; and rigors, high fever, typhoid tongue, and œdema of the parts in the neighborhood of the injured organ will telegraph the mischief immediately threatening life.

There is no question, however, that a rupture of the kidney need not be necessarily fatal. The following case is a fair illustration of recovery from such an accident.

A man, aged thirty-seven, in June, 1858, was taken to St. George's Hospital, having been kicked by a horse. The patient was very faint on admission, and became so much worse after a very short time, that it was supposed he was dying. However, he rallied by degrees. After a short period, a swelling was observed in the region of the liver. The belly commenced to swell, and continued to do so for some time. The urine at first passed was mixed with blood; on the day following the injury, there was less appearance of blood; and, subsequently, the urine was free from blood. He gradually recovered under careful treatment, so as to leave the hospital July 20, about six weeks after the accident, in a pretty good state of health and comfort. On Dec. 14, 1859, he was readmitted, suffering severely from anasarca, oppressed breathing, and urine loaded with albumen. He died Dec. 22.

There were numerous adhesions uniting the right lobe of the liver to the diaphragm, but there were no absolute marks of recent rupture. Both kidneys were small, granular, and full of cysts. The cellular tissue around the right kidney was much consolidated. A large clot of blood occupied the pelvis and the interior of this kidney, and communicated also with the exterior of the organ, where a considerable quantity of coagulum lay in the subperitoneal substance around the gland. The line of rupture of the kidney could be faintly traced through the substance of the gland. The blood was solid, and only partly decolorized. The ureter was completely impervious with coagula.[1]

We may conclude that recovery is a result almost entirely dependent on the extent of rupture; if the latter be slight, recovery may readily occur—if extensive, treatment is hopeless and death certain.

A man was admitted into St. George's Hospital, under the care of the author, with severe pain in the right side of the abdomen and loins; the result of a fall. The urine drawn off was loaded with blood. There was much tenderness on pressure, and some tumefaction with resistance of the abdominal muscles on the side affected. Symptoms of acute peritonitis supervened, and the patient died in a few days.

A post-mortem examination disclosed a kidney nearly divided in two, on the right side, with extensive extravasation of blood around

[1] Prize Essay, by Mr. Poland.

[1] Path. Soc. Trans., vol. xi., p. 140.

the damaged viscus, but confined to the subperitoneal cellular tissue, and mixed with fetid purulent fluid, apparently the result of urine extravasated, and escaping from the lacerated pelvis of the kidney. There was no escape of blood or urine into the cavity of the peritoneum.

Absolute rest is the first consideration in treatment. Should vomiting or pain set in, opium should be administered freely, care being taken to relieve the bowels moderately. The urine should be drawn off, in order to ascertain whether blood be contained in the bladder; and should this be the case, the use of the catheter should be had recourse to daily, until the urine becomes clear. Supposing the mischief to have been confined to the posterior surface of the kidney, and we have reason to suspect extravasation of urine through the wound, we must be prepared for suppuration. Frequent and careful examinations should be made, in order that an exit may be secured for the matter, as soon as its existence is suspected; we would strongly urge the advantage of a premature opening, in anticipation of the formation of matter, rather than that any delay should occur in giving it vent, when once established. Suppuration in the lumbar region spreads rapidly, and produces intense constitutional irritation, and will prove in most instances rapidly fatal. But should matter extend downwards and forwards, free incisions early made afford the best prospect of recovery to the patient.

In the 27th volume of the Medico-Chirurgical Transactions, Mr. Stanley has reported two cases of ruptured ureter. A boy, aged nine, had the lower part of his body squeezed between a wheel and the curb-stone. The result was severe contusion of the soft parts around the pelvis, and inability to walk, with great pain at the lower part of the abdomen. Much ecchymosis ensued and was followed by extensive suppuration in the subcutaneous tissues round the pelvis; and several ounces of matter were discharged through a puncture near the left sacro-iliac symphysis. By the end of the sixth week, recovery of the injured soft parts round the pelvis had considerably advanced, when attention was drawn to a fulness on the right side of the abdomen—a circumscribed oblong swelling, extending from the base of the chest to within a short distance of Poupart's ligament; anteriorly terminating abruptly at the linea alba, posteriorly extending into the lumbar region, but without a distinct boundary. Pressure produced no pain, but fluctuation could be recognized. The urine passed naturally, as it had done throughout, and the passage of the catheter proved that none was retained in the bladder. A small puncture was made in the swelling, and a little clear yellow fluid escaped. The fluid was situated immediately beneath the abdominal muscles. Three weeks subsequent to the first puncture, the swelling being more tense and pointed, a trocar introduced midway between the last rib and crista ilii drew off 51 ozs. of clear yellow fluid. Eleven days afterwards, 58 ozs. of clear yellow fluid were drawn off; sixteen days subsequently, 64 ozs.; nearly three months afterwards, 72 ozs. Three weeks after this, only 6 ozs. were removed. "From this period the swelling was without increase or obvious diminution; it still extended from the linea alba into the right lumbar region." At several subsequent periods Mr. Stanley saw the boy in good health, the abdominal swelling still distinct, but slowly diminishing. The fluid drawn off was slightly alkaline, highly albuminous, specific gravity 1008, depositing no precipitate, and destitute of phosphates and lithic acid. In some of the fluid taken away at the later operations, there were most unequivocal evidences of urea. "*The analysis of the fluid seemed to justify the conclusion that the fluid was urine.*"

The second case was that of a woman who was knocked down by, and pushed some way before, the wheel of a cart. She was much hurt in the right hypochondrium, where pressure gave considerable pain. In a few days the general distension and pain of the abdomen had subsided, but there remained a circumscribed swelling in the right hypochondrium. This swelling increased, and after some days a feeling of deep fluctuation was discovered. The fluid advancing nearer to the surface, and the constitutional symptoms indicating the occurrence of suppuration, the swelling was punctured with a small trocar, and between two and three pints of straw-colored urinous-smelling fluid drawn off. The urine from the bladder had throughout passed freely and in full quantity. In ten days subsequent to the first puncture, a trocar was again passed in, and about six pints of fluid drawn off. Much relief was at first afforded, but subsequently the patient sank, and died in the tenth week after the accident.

"A large cyst was found on the right side of the abdomen, behind the peritoneum, extending upwards to the diaphragm and downwards to the pelvis. The boundaries of this cyst were formed by lymph and thickened cellular tissue; within it was a large quantity of fluid, presenting the characters of a mixture of pus and fetid urine. A passage was found extending from the upper part of the cyst into the pelvis of the right kidney. The aperture in the pelvis of the kidney was large and irregular; the appearances were such as might be expected to result from laceration of the membranous structure composing the pelvis. The liver presented in its anterior surface the marks of a slight laceration of its tissue, which was in progress of healing."

Mr. Stanley adds: "It will, I presume, scarcely be doubted that the case first stated was an instance of lesion of the urinary apparatus, probably a slight laceration of the ureter; permitting the escape of urine slowly into the cellular tissue behind the peritoneum. Both cases illustrate the difficulties that may arise in the diagnosis of such injuries. They show, moreover, that the rupture of the ureter, or pelvis of the kidney, may present this remarkable feature, when contrasted with the consequences of a rupture of the bladder,—that whilst in cases of the latter injury, symptoms immediately arise, directly pointing to the organ which has suffered, in cases of the former kind (the lesion of the ureter or pelvis of the kidney) no symptoms may immediately arise

leading to a suspicion of injury to any part of the urinary apparatus."

We have already alluded to the possibility of recovery after laceration of a kidney on its posterior surface. The cases recorded by Mr. Stanley tend to confirm this view; and they also indicate the advantages of an early exit being given to the contents of any abscess, or cyst, the result of extravasation of urine. Regarding this point of treatment, Mr. Stanley observes: "It may, however, be a question whether the best proceeding would be gradually to withdraw the fluid by repeated punctures of the cyst, and thus to favor the collapse and adhesion of its sides, or whether the urinary cyst should be punctured at its lowest part, in the view of maintaining the aperture free for some time, that the fluid may drain from it." Provided the fluid be at all purulent, the latter method of treatment would no doubt be most judicious.

Wounds.

1. *Wounds of the parietes without protrusion of viscera.*—We now enter upon that division of our subject which treats of wounds of the abdominal wall, occasioned by a variety of weapons or instruments, without injury to, or protrusion of the viscera. Wounds of the walls of the abdomen are very common, and occur from a great variety of sharp or pointed substances, intentionally or accidentally thrust against, or that suddenly come in contact with the surface of the belly.

Sharp or pointed instruments usually produce clean incised or small penetrating wounds. The larger wounds of the abdomen are the results of persons being caught on hooks, or impaled on iron spikes; falling on china, or through glass; being tossed by horned cattle, or lacerated by the teeth of carnivorous quadrupeds. The extent and character of such wounds will therefore vary in every possible degree, and will depend in as great a measure upon the amount of force by which the instrument of injury is propelled, at the time of the accident, as upon the shape of the instrument and the direction in which it enters the body.

Superficial incised wounds of the abdominal wall are not generally dangerous in their character, nor troublesome to manage, provided the viscera escape bruise or other injury at the time of the accident. Lacerated wounds, when superficial, may also be considered free from much danger. But deeper wounds, whether incised or lacerated, without injuring the peritoneum, are more serious; from the fact, that there is always a liability to suppuration, burrowing deep, and extending in various directions under the muscles and fasciæ. The principles laid down for the treatment of wounds in general must be applied to those of the abdominal wall. Hemorrhage, if it exist, must be arrested. Care must be taken to clear the wound of any foreign substance accidentally lodged in it; such as glass, china, or portions of instruments broken off by the force of the blow which inflicted the injury. It has frequently occurred that large foreign masses have been overlooked, and allowed to remain buried, for many months, in the muscular wall of the abdomen after an accidental gap made by some sharp cutting material.

A sailor was admitted into St. George's Hospital, complaining of pain over the right lumbar region, produced apparently by some solid substance lodged underneath the integuments. Mr. Babington cut down upon the mass, and extracted the shaft of an originally three-pronged steel fork, now minus a handle, and with only two prongs attached, one prong having been broken off some time previously.

Scrupulous attention having been paid to the condition of the wound, and it having been ascertained to be free of any foreign substance, the treatment should be very simple. The abdominal muscles are to be relaxed by position, especially if the edges of the wound have the least inclination to retract. As a rule, sutures will be found most advantageous and effective in approximating and retaining the edges in apposition. Metallic wire sutures appear to offer many advantages over silk, in such cases.

It must, however, be borne in mind that in wounds of any depth about the abdominal walls, especially in the thicker parts, or wherever the muscles overlap each other, it will be found difficult, if not impossible, to maintain perfect apposition of the whole surface of the cut. There is always in such wounds a tendency for fluid, serous or sanguineous, to accumulate between the surfaces at the deepest parts. The existence of such fluid may be followed, in a comparatively short time, by foul suppuration; which, if allowed to remain confined, would produce alarming constitutional disturbance.

A man, æt. 31, was admitted into St. George's Hospital, on May 22, 1839, with femoral aneurism on the left side. The external iliac artery was tied by Sir B. Brodie on May 30. On the evening of the day of the operation, there was much pain about the wound, and the parts were very sensitive to pressure. The tongue was already brown and dry. On the following morning, the pain was more diffuse, but less intense; the tongue still brown and dry. The left side of the abdomen was hard and tender to the touch. The next morning, June 1, the pulse was 136, and small; the tongue brown and dry; countenance anxious; pain only referred to the neighborhood of the wound. The

adhesions of the wound were now broken down by Sir B. Brodie, and much sanious putrid fluid immediately escaped. The same evening the patient felt relieved; and the tongue became rather more moist. Subsequently, he continued to improve, and although some time recovering, he was entirely restored to health, and left the hospital about seven weeks after the operation.

In the treatment of the various wounds of the abdominal wall, however produced, it is always necessary to bear in mind that the treatment should be somewhat modified by the locality of the mischief. For instance, in the epigastric region a wound is apt to gape more than when situated in another part, on account of its proximity to the ends of the ribs, which tend to keep the integuments in that region always somewhat on the stretch. It will, therefore, be uniformly requisite to have recourse to sutures to maintain perfect apposition of the cut surfaces. If, again, the muscles are cut or torn, on either side, transversely to the direction of their fibres, attention should be more especially directed to the position of the body, to relax those muscles. If the wound be in the iliac region, it may be more formidable in its real than in its apparent character; not so much from its extent, as from its depth and its direction, and from the risk of the iliac arteries, or their numerous branches, being punctured or bruised.

We have already stated that if hemorrhage exists, it should be arrested. The treatment of hemorrhage does not fall within the province of the present essay; but perhaps we shall be excused if we trespass out of our province on this one occasion, and speak an extra word or two of caution to the practitioner who may have to deal with hemorrhage in a wound of the abdomen. If there be severe hemorrhage, and the wound not sufficient to allow the bleeding mouth of the vessel to be seen, no hesitation need be felt regarding treatment. The wound should be enlarged—enlarged until the wounded vessel can be seen, *and can be secured.* We need not fear hemorrhage so long as such a wound is open, and we can place a finger on the bleeding point. When the surgeon trusts to external pressure, and closes the wound without securing the wounded artery, then there is abundant cause for anxiety. If these principles be of importance in hemorrhage of ordinary character, they are tenfold important when applied to the treatment of wounds in the region of the groin, or the neighborhood of the crest of the ilium.

If hemorrhage be present from a punctured wound, but not in sufficient quantity to indicate the necessity of enlarging the wound, for the purpose of securing the wounded vessel, the wound should not be closed, otherwise much extravasation may occur. To close such a wound under such circumstances is likely to entail extravasation among the deeper tissues, to be followed perhaps by much suppuration. It will be far more prudent to leave a punctured wound with merely some light application over it, such as wet lint, and thus permit oozing to continue unchecked, than attempt to interfere with such bleeding by pressure.

Punctured wounds of the abdominal region, as in all other parts of the body, partake of a more complex and dangerous character than the incised or lacerated varieties. It is frequently difficult, sometimes impossible, to ascertain the extent of the mischief, or foretell the evils about to occur in a punctured wound of the abdomen. Mr. Poland, writing on such wounds, justly observes that "they are not unfrequently followed by inflammation, suppuration, erysipelas, prostration, and death." Punctured wounds prove most troublesome when they extend below the fasciæ of the abdominal muscles, and give rise to suppuration. In such instances the mischief spreads rapidly in the deeper cellular tissue, and between the layers of muscles, unless early relief be afforded by freely extending the original wound. In instances of the above injury, if the external wound be kept closed, and much extravasation have occurred, the suppurative stage occasionally produces excessive constitutional disturbance, and may even prove rapidly fatal.

We would lay it down as a rule, firstly, that *in punctured wounds* of the abdominal wall, if *any* hemorrhage be present, but not sufficient in amount to justify or indicate an enlargement of the wound for the purpose of applying a ligature to the bleeding vessel, the exit of the flowing blood through the orifice of the wound from the injured artery or vein should not be checked by outward applications. By far the less of two evils will be to allow the blood to escape externally, rather than by external appliances to insure its accumulation in the tissues surrounding the wound. We would lay it down as a rule, secondly, that if hemorrhage be at all free, the wound should be enlarged sufficiently to allow the bleeding vessel to be secured, and no dependence should be placed on pressure to restrain such hemorrhage. We would also lay it down as a rule, thirdly, that with the earliest suspicion of suppuration the wound should be freely opened, and a ready escape afforded to the blood, serum, or pus now collected within.

The extent of a punctured wound will always to some degree regulate the subsequent amount of mischief. If it penetrates

through the muscles, but not the peritoneum, the wound may prove fatal from peritonitis secondary to the suppurative stage, if not fatal from peritonitis the immediate result of the accident.

Under all circumstances, therefore, the utmost precaution in treatment is necessary. Perfect rest; relaxation of the abdominal muscles, by a posture somewhat bent forwards; the stomach and bowels to be kept moderately empty by the administration of fluid food only; and the administration of opium as indicated by symptoms, will constitute the chief points of medical management. The local treatment of the wound is not a consideration of importance here; if there be suppuration, *the point* beyond all doubt is, that it have free vent; irrespective of *that*, the treatment is of the simplest kind. Peritonitis supervening on these accidents cannot often be met by active or heroic treatment; leeches should not be spared if necessary and if the patient can bear the loss of blood. The practitioner will find in most cases an invaluable auxiliary in opium; but science, judgment, and experience must regulate the treatment in each individual case, according to symptoms. No definite law can be applied to the complications which so often arise in the progress of these cases.

Suppuration will be indicated by increase of heat about the wound, redness, tumefaction, and tenderness. These symptoms will soon be followed by heat of body, increase of pulse, thirst, a brownish dry tongue, rigors, and perhaps wandering sleep or delirium. It may even happen, if the wound be deep, and the symptoms severe, that the constitutional disturbance is so rapidly increased in amount that death takes place in an unexpectedly short period. It is well, at all times, to be very guarded in any opinion offered to the anxious relatives of a patient, the subject of such an accident. In rapidly fatal cases the cellular tissue and the fascial interspaces will usually be found infiltrated with pus and lymph to a surprising extent; and not unfrequently purulent effusion will be observed on the surface of the intestines.

Should the patient survive the early inflammatory and suppurative stages following a punctured wound of the abdominal wall, the suppurative action may spread at intervals in various directions, and abscess after abscess present in different positions until he becomes worn out and dies; or sometimes when the patient may be said to have placed his hand on the door leading to death's chamber, the symptoms commence to show a favorable turn. Suppuration becomes healthy in character and diminished in quantity. Sinuses gradually close, and time slowly replaces the sufferer in a position of safety; he rises from his couch convalescent, but most probably somewhat crippled, either from suppuration having extended below Poupart's ligament and having implicated the muscles of the thigh or neighboring articulations, or from the contracted position in which, for many weary days, he has been confined to bed.

In the abdominal wall a condition sometimes remains, after a wound of the parietes has healed, to which the attention of the surgeon must be directed—we allude to the protrusion of the parietes at this part. This protrusion is the result of the action of the abdominal contents against the cicatrix, which thins out and yields more readily than the natural healthy abdominal wall. Such a protrusion constitutes one of the forms of ventral hernia. Usually the protruding viscera push before them evenly the now stretched cicatrix and surrounding tissues, so that the base of the prominence is larger in circumference than any other portion. There is no so-called neck to the cavity which contains the viscera, so that the latter run little risk of strangulation. No difficulty is encountered in an attempt to push back the contents of the prominent mass; the difficulty is to restrain the viscera from again bulging forward. As there is no danger of strangulation, it is only necessary to support the parts by means of a large pad and a well-adjusted bandage.

2. *Wounds of the abdomen, with protrusion of the bowels or portions of the viscera* through the aperture, are by no means rare accidents; such a protrusion constitutes a hernia without a sac.

The character of the wound will in a great measure regulate the amount of the protrusion, just as the situation of the wound will to some extent permit only certain viscera or portions of them to be protruded. In punctured and small wounds a part of the intestine, omentum, or both, may escape through the aperture. In incised or lacerated wounds larger portions of either, or both, and even portions of the stomach, liver, etc., may protrude externally. In the former kinds of wounds the protruding viscera are very apt to be constricted at their point of exit from the cavity of the abdomen; a condition little liable to happen in the lacerated or large incised wounds. The viscera most frequently met with protruding through the wounds of the parietes of the abdomen are the small intestine and omentum; for as the mobility of the part, so is the greater facility of its displacement. But stomach, large intestine, and even liver and spleen, have been found lying outside the abdomen in wounds, the result of accidents such as we are about to consider.

We presume, as the first consideration

in treatment, that the surgeon, in dealing with protrusion of any portion of the viscera through a wound of the abdomen, has a recent accident before him. In such a case he has no time to lose in returning the protrusion, whatever it may consist of, whether omentum, intestine, or other tissues. What considerations should guide his proceedings? In the first place, having by careful examination satisfied himself of what the protruded portion consists, he must see that no foreign substances adhere to, or are entangled in, the protrusion. If such be the case, the parts must, with gentleness and caution, be cleansed with tepid water, to free the peritoneum of all extraneous matter, and to secure a *perfectly* clean surface. If the portion protruded is *apparently* omentum alone, care must be taken to ascertain that bowel is not wrapped up in the folds, or lying at the base of the protrusion near the aperture of the wound. If the protrusion consist of intestine, care must be taken to ascertain that no injury has been occasioned to the peritoneum, or that the coats have not been ruptured. These points being ascertained, the parts being sound and healthy, and the surface perfectly clean and free from extraneous matter, the replacement of the protruded mass into the abdominal cavity should at once be proceeded with. A ready replacement is not always easily effected. In such a difficulty it will sometimes answer to draw out a small portion more of the intestine, and then on gently pressing upon it, and propelling its contents into the interior, the protruded bowel will itself sometimes readily follow. It may happen that such a large amount of intestine or omentum has escaped through the wound, that the protruded portions can no longer be passed back through the opening by which they escaped. Under such circumstances the surgeon need not hesitate; for as in a case of strangulated hernia, so here, the orifice, or stricture of the wound should be enlarged. If this alternative be inevitable, care must be taken to avoid enlarging more than the external orifice of the wound, or dividing more than any bands of fascia or fibres of muscles that offer obstruction to the return of the protrusion. The peritoneum should not be interfered with if this can possibly be avoided. The opening in the peritoneum will readily yield to any extension requisite for the reduction of the protruded viscus; but if the opening in the peritoneum be increased by incision, the enlarged wound will hereafter be found to facilitate, to a most troublesome degree, the reprotrusion of viscera through the peritoneal opening. The external opening being, either of itself or by extension, sufficient for the reduction to be proceeded with, the protruded parts should be gently returned, bowel first, and omentum after it, should both have escaped. The surgeon should then satisfy himself that all is fairly returned within the cavity of the peritoneum. The structures which protruded should not be heedlessly or hastily reduced, for they may be pushed simply between the external tissues and the peritoneum, without having been returned into the abdomen, and they would then still remain subject to the constricting influences of the internal orifice of the wound. In all cases, *subsequent* to the reduction of the parts, the finger of the surgeon should be gently passed down to the peritoneal aperture, to ascertain whether any portion of viscera still occupies this opening, in which case he should insure perfect reduction previous to closing the wound.

Supposing omentum to be the only structure protruded through such a wound, something depends on the condition, something on the quantity extruded, and something upon the nature of the wound, before we can decide to return it into the abdomen. If the omentum be quite healthy, recently protruded, not congested, not lacerated—whether it be much or little in quantity—and if the wound permit of its ready return, there can be no doubt that, to return the mass at once, and to close the wound, is the practice we should adopt.

If the omentum be bruised, lacerated, dirty from contact with the ground or other material, inflamed or congested, or if the mass be not considerable, but there be much resistance to its reduction, without enlarging the wound, we would recommend a ligature to be passed round the base of the omentum, or a double thread to be passed through it, and the mass anterior to the ligature cut off.

If the protruded mass be very large, and not injured, but the wound not sufficient to allow of a ready return, the wound should be enlarged, and the parts replaced; but if a large portion be in any degree bruised, lacerated, or congested, or if blood be extravasated in its structure, it may be removed with safety, and its removal will be probably less serious than if it were left in the wound to suppurate or slough, as the case may be. In very many cases of inguinal and femoral hernia, it has occurred to the author to consider it desirable to remove portions of omentum, occasionally considerable portions. He has never had reason to regret the adoption of such a proceeding, but has had occasionally to regret its omission. If such treatment be applicable in the one class of cases, we cannot reasonably condemn it in the other; and under the circumstances above mentioned, it appears to be the most judicious, and the most expeditious, towards favoring the recovery of the patient. It must, however, be stated

that there are some differences of opinion on this point. The opinion now arrived at is the result of a careful consideration of the practice observed at St. George's Hospital for many years past. Be it remembered, however, that whether the omentum be returned, or whether removed, the external wound should be brought together at once, and should have nothing protruding between its lips, except the ends of the ligature passed round the omentum. [In the light of present experience, in the use of ligatures in ovariotomy when adhesions must be torn and vessels ligated, it is safe to predict, that the practice of leaving the ends of ligatures hanging out of abdominal wounds, in cases in which the omentum has been tied and cut, will not long be continued; but, that the ligatures will be cut short and returned with the omentum into the abdominal cavity]. The removal of omentum *must never be attempted under any circumstances*, without the base of the portion to be removed being safely secured by ligature. If this precaution be not heeded, very formidable, if not fatal, hemorrhage may result from the vessels divided. And again, it is safer to pass the double ligature through the base of the omentum rather than trust to a single ligature tied round it; we thus avoid the possibility of the ligature escaping from off the stump of omentum, which is left in the wound after the greater portion of the protruded mass has been cut away.

With the exception of omentum, all other protrusions of viscera must be invariably reduced, and as early as possible.

It has been already stated that the small intestine is more frequently protruded than portions of other viscera, after wounds of the abdomen; the transverse colon and the stomach come next, each in its order. The wound of the parietes must be extensive to allow of the protrusion of liver or spleen. But yet there are cases on record, and those not few, which bear witness that portions of most of the viscera may escape through an opening in the abdominal wall. In a practical point of view it does not matter what the protrusion may consist of, irrespective of omentum; for, provided the mass be healthy, *it must be returned.* It is only the amount of the protrusion which will to some extent affect the steps of the treatment: for if the wound be small, and the mass protruded large, in all probability the former must be enlarged before the latter can be returned. In lacerated or incised wounds the probability is that reduction is readily effected.

The rules propounded respecting the propriety of reducing the omentum when protruded, will apply to some extent to the treatment of protruded intestine. The latter, when examined soon after an accident, may be found reducible readily through the wound. In such case the precautions necessary are, to see that the intestine is clean—its surface free from dirt, hairs, straw, or other matters which the contact of clothes, etc., may occasion to adhere to the moist peritoneal covering; that the bowel is not bruised or ruptured; that no portion of the instrument which occasioned the wound is lodged among the folds of the intestine. The surface of the bowel must be well cleared of all adherent materials, by being bathed gently with tepid water, and, if otherwise sound, be at once returned into the abdomen.

If the bowel, as regards its integrity, etc., be in a condition favorable for reduction, we may nevertheless find that it is irreducible. This circumstance may be the result of a great amount of viscera protruded, or of the protruded portion having become much distended by flatus, or thickened by congestion—or of a wound, contracted when compared with the size of the mass external to it. If the difficulty in reduction arises from the smallness of the wound, the means to be adopted have already been mentioned. If such difficulty depends on the distension of the bowel by flatus, that condition may often be overcome by very gently and carefully pressing the air back into the portion of intestine within the abdomen. This attempt, however, may entirely fail, and only by an extension of the wound can a very large mass of greatly-distended intestine be returned into the abdomen. In instances of very large protrusion, with *excessive distension*, to puncture the bowel with an exploring needle is a practice which has been adopted successfully; but, on the other hand, such practice has been strongly condemned by several writers. It has been urged that the small punctures cannot be of service, as they will soon be filled up by the mucous coat. However, as they are only wanted for immediate relief, this objection is not of much value. Such treatment can only be requisite in extensive protrusion of bowel largely distended, and where there is much difficulty of reduction.

Mr. Tatum reports a case in which he adopted this treatment with success. A patient was operated on for inguinal hernia, and the medical man found after dividing the stricture, that so large a mass of bowel protruded that no effort on his part would succeed in reducing it. Mr. Tatum was called in, and examining the condition of the parts, found the space between the thighs occupied by a large volume of intestine, extending nearly down to the knees. "It was found to be composed of the whole, with a slight exception, of the jejunum and ileum, enormously distended with flatus, and of a bright-red color." With a grooved needle, Mr. Tatum made three or four punctures, allowing the flatus to escape by the

groove in the needle at each puncture, until the part was collapsed. "By these means the whole of the protruded bowel lay in a collapsed state, not one-fifth of its previous volume. The protruded parts were now readily returned into the abdomen;" and the patient recovered without a bad symptom.[1]

In all other conditions of irreducible intestine, the wound has to be enlarged before the attempt at reduction can be successful. Great care and much gentleness are requisite in handling a portion of bowel when the reduction is attempted; observing carefully the manner in which the coils of the bowels lie with regard to the wound, the surgeon should commence manipulation with the portion last descended, and nearest the margin of the opening; and should keep passing up portion after portion by degrees, until the whole mass is returned. This process, though apparently simple in its description, is often very perplexing at the bedside; such an attempt sometimes appears almost hopeless; for as one portion is pushed back, another portion is forced out of the abdomen. Every precaution is therefore requisite to lessen the muscular action of the parietes; the abdominal wall must be perfectly relaxed; the patient made to lie on his back, with his shoulders well raised, and the thighs perfectly flexed on the pelvis. If it be necessary to enlarge the wound, we should be careful to enlarge it in the direction of the muscular fibres, and away from the course of the epigastric artery, and to avoid enlarging the opening in the peritoneum if possible. It is necessary to ascertain that the bowel when reduced is returned entirely within the peritoneum.

The bowel protruded may be not only irreducible, but it may, as occasionally in herniæ, be also strangulated: of course this condition occurs only when a patient has been left, for some time after the accident, without medical aid or relief. The amount of mischief to the bowel, resulting from the strangulation, must be our guide as to whether any *positive* benefit is likely to be derived from its reduction; but, short of a state of gangrene, it were better to return the bowel at once, and so secure the best chance for the recovery of the patient. The wound should at once be enlarged, and the protrusion returned. In a condition of gangrene, if the gut is returned into the cavity of the peritoneum, death must ensue. The only treatment which holds out a prospect of life, with so much mischief, is to open the bowel at once, to allow its contents to escape, and then to leave the intestine, now adherent to the margins of the wound, in undisturbed possession of its new attachments. An artificial anus will thus be established. We shall hereafter consider the treatment of this lesion.

The treatment of all wounds of the abdomen, after the reduction of protruded viscera, whatever the character of the latter, is simple enough. The parts around the wound must be relaxed, and this relaxation be maintained by position. It is desirable to close the wound at once, and, in most cases, sutures are to be preferred, to secure uniform apposition of the edges, as well as to maintain perfect support. In the application of the sutures, it is desirable that the peritoneum be included in their hold as well as the more superficial tissues. Such a proceeding should not be considered more dangerous than if the suture be simply confined to the superficial margins of the wound. By including the peritoneum, we secure the perfect apposition of its edges, and thus prevent the escape of intestine into the gap of the deeper part of the wound, and also to a great extent prevent the products of suppuration escaping into the cavity of the peritoneum. Whenever a ligature has been applied to the omentum, the ends of that ligature should be allowed to hang out of the wound, between any two sutures applied to its margin, until separation from the hold on the omentum takes place. The period of separation varies from nine or ten days to sometimes a fortnight or three weeks. The dressings applied to the wounds cannot be too simple or too light.

[In cases of abdominal wounds, and especially those in which the viscera have remained exposed for some time and when peritonitis may be feared, it is good practice after the wound is carefully and perfectly closed to apply an antiseptic dressing. Cover the abdomen with an abundance of cotton-wool and apply a body bandage snugly. It will serve not only to support the weakened wall of the abdomen, but also the intestine, weakened by inflammation, will thus aided be enabled to resist the pressure of accumulating gas.]

The following case is a fair specimen of recovery after a large lacerated wound of the abdomen. A man, whilst leading a prize-bull to an agricultural show, was suddenly attacked by the animal, and gored at the lower part of the abdomen. The patient was seen soon afterwards by Mr. James, of Uxbridge, who found a large quantity of the small intestine and omentum protruding through a lacerated wound, some eight or nine inches in length, passing directly across the body, midway between the umbilicus and pubes. When seen first by Mr. James, the intestines were covered with dirt, and had adhering to their surface particles of straw, etc. The parts were carefully cleansed with tepid water, and all ex-

[1] "Cases of Hernia, with Remarks," by Thomas Tatum, Medical Times and Gazette, April 29, 1854, p. 433.

traneous matter removed from the peritoneum; the intestines and omentum were then returned into the cavity of the peritoneum, and the edges of the wound brought together by several silk sutures. The man was then sent in a cart to St. George's Hospital, a distance of fifteen miles, and placed under Mr. Cutler's care. On the morning following admission, the wound looked perfectly united. There was some tenderness about the abdomen, but nothing of a severe character. The pulse was not irritable; the tongue rather white; but the patient stated himself to be pretty comfortable. He had not one bad symptom subsequently. The wound entirely united by first intention; and the man left the hospital in a short time quite well, and without any discomfort from the injury.

The stomach, portions of the liver, or the spleen, may escape through a wound in the abdominal wall, as we have already stated, but the principles laid down for the treatment of protruded intestine will, in a great measure, apply to these complications. Mr. S. Cooper mentions that in his part of the Military Hospital at Brussels, after the battle of Waterloo, the number of patients admitted with protrusions of the viscera was much more considerable than previously he had any idea of meeting with,—protrusions of stomach, bladder, mesentery, omentum, and intestine.

Dr. John Macpherson, of the Bengal Medical Service, relates a case of spear-wound, with protusion of liver, in a Hindoo. The wound was an inch in length; about three inches above the umbilicus, and about two inches to the right side. Through the wound, a triangular portion of liver protruded. There was much hemorrhage, but no apparent wound of the liver. It was found impossible to return the protrusion without enlarging the wound. A ligature was tied round the base of the prominent piece of liver, and the greater portion cut off; a double ligature secured the remainder to the edge of the wound. The patient recovered.[1] We may remark that the natives of India are singularly happy in recovering after surgical operations.

Many other cases could be added to illustrate not only the possibility, but the fair prospect of recovery after wounds of the abdomen, with protrusion of viscera, provided the viscera are not injured nor the peritoneum bruised. The following case, however, is a marked instance of an unusual character of accident, as well as an illustration of a difficulty, which creates some kind of doubt as to the most advisable treatment to be adopted. For the notes of the case the author is indebted to his friend, Mr. Godson, of Barnet. "A woman, æt. 63, on July 11, 1854, was seriously injured by the brutality of four men committing rape upon her. The following morning she walked nearly a mile, with several convolutions of the small intestines protruding externally through a rent in the vagina. The intestines, when seen by Mr. Godson, had particles of straw and dirt adhering to their surface, but the woman did not appear to suffer very much pain, though apparently very ill. The parts were cleansed with tepid water, and the patient was put to bed in the workhouse. Mr. J. H. Green subsequently saw the patient, in consultation with Mr. Godson. All attempts at reduction were found unavailing; nor did there appear any possibility of enlarging the wound to facilitate the reduction of the bowel. The protruded portion became gangrenous on the 14th, but the patient lived until the 21st, ten days after the injury. The rent was found in the anterior wall of the vagina, close to the uterus, and running into the cavity of the peritoneum between the bladder and uterus."

[1] Medical Gazette, Jan., 1846.

It is somewhat difficult to advise what proceedings should be adopted in any case similar to the above. There appeared no possibility of returning the bowel by manipulating the protrusion itself; nor did it appear possible to get at the opening to enlarge it, the vagina being filled with intestine. The treatment which appears most suited to such a case, and which should be adopted if the result of this case is to influence us, would be to make an incision through the abdominal wall in the median line and below the umbilicus, and to introduce the hand, so that the bowel might through this opening be drawn back into the abdomen from the vagina. The treatment would be desperate; but without some effort at reduction such a case is hopeless. Such treatment ought only to be adopted as a last resource, and only after the failure of local attempts at reduction, assisted by raising the lower part of the trunk, so as almost to place the patient with the head below and the pelvis above.

Protrusions of the spleen have been recorded as successfully treated, either by reduction, or even by removal. One singular case of the latter description is to be found in the Phil. Trans., vol. xl., p. 425, in which instance the patient recovered, and lived without apparent suffering from the loss.

In protrusions of the bladder, it is always requisite to introduce a catheter through the urethra without loss of time, and to draw off the urine. This treatment will, we believe, in all cases sufficiently reduce the size of the protrusion to permit its reduction without difficulty.

The latter protrusion may occur subsequent to a wound of the abdominal wall without a wound of the peritoneum. The protrusion will only occur, under any condition of wound, when the bladder is somewhat distended, for an empty bladder lies behind the pubes in close contact with the anterior bony wall of the pelvis. Provided there be no injury to the bladder, the simple protrusion, unaccompanied by peritoneal injury, is an accident that may produce very little subsequent inconvenience, even if the whole of the external wound does not unite immediately. If a wound of the

lower portion of the abdomen be complicated with wounded peritoneum, and a punctured bladder permit the escape of urine into the sac of the peritoneum, severe peritonitis rapidly follows upon the injury, and death soon takes place. The further consideration of lesions of the bladder will be found under the head of INJURIES OF THE PELVIS.

Before concluding this portion of the subject, it may be mentioned that occasionally, but rarely, subsequent to a wound of the abdomen, peritonitis may terminate in the formation of an abscess, confined to a proportionately small space in the peritoneal sac, and that such abscess may of itself open externally, or require the aid of the knife to allow of the exit of matter. We can rarely anticipate a favorable result in such a case; for we should generally find the intestines matted together in the neighborhood of the abscess, and frequently a fistulous communication established between the abscess and the intestines forming a portion of the circumference of the sac. In such cases suppuration and diarrhœa play upon a system already reduced by previous illness, and the patient sooner or later sinks under the exhausting influences of the local mischief and constitutional disturbance.

3. *Wounds of viscera* may be classed, for the convenience of consideration, into, firstly, those which occur in protruded portions; secondly, those which occur from penetrating wounds of the abdomen.

In the examination of the first-mentioned variety, we have here to consider the nature and treatment of *the wound alone*. All that relates to the management of the protruded bowel has already been fully discussed, and requires no recapitulation.

Wounds of the intestine may vary very considerably in size as well as in appearance, according to the shape and character of the instrument by which the lesion is occasioned; and the treatment must be regulated very much according to the extent of the wound.

A small wound of the bowel, whether of the small or large intestine, produced by some pointed instrument, or by a sharp knife, when seen *immediately* after the injury, would present little more than the wound in the peritoneum, for the deeper gap would almost instantaneously be filled with mucous membrane. The fæces are not observed to escape through so small a wound. In a very short time after the receipt of the injury, the entire wound would be found plugged with mucous membrane, and the latter would soon project above the level of the surface of the peritoneum, become everted over its margin, and thus effectually conceal the exact limits of its orifice. A pair of forceps applied to the intestine at the injured part will enable the surgeon to raise up this portion, and pass a very fine ligature immediately round the puncture, so as to include it entirely. The ligature should then be tied firmly, and the ends cut off close to the knot. The bowel should be returned as directed.

Some surgeons have considered it unnecessary, and not even desirable, to apply a ligature round *a small punctured wound of intestine*. They have argued that the mucous membrane so entirely blocks up the orifice in such a wound that escape of the contents does not occur, and that the application of the ligature is only apt to aggravate the tendency to peritonitis. But it must be evident that the application of a ligature to the wound, however small, of the intestine will entirely prevent the escape of any feculent fluid into the peritoneum, and thus will constitute one great measure of safety in treatment; nor is it at all evident that the presence of the ligature is prejudicial. The adoption of such practice has been successful in very many instances.

Mr. Travers, in his work on Injuries of the Intestines, has recorded several experiments on animals, the results of which tend to prove that a wound of the intestine is generally fatal from the effects of peritonitis. All the experiments by Mr. Travers, Dr. Gross, and others, lead to this conclusion, that, upon the infliction of a wound of the intestine, *some* escape of feculent fluid, though perhaps a very small quantity, takes place, and is the chief cause of the subsequent peritonitis. The escape of the very smallest quantity of such a fluid appears sufficient to produce violent peritonitis; and it appears, therefore, more just to ascribe the peritonitis following a wound of the abdomen, complicated with a wound of the intestine, to some escape from the latter rather than to attribute the mischief to the wound of the peritoneum.

A simple wound of the peritoneum, without a corresponding opening in the intestine, is a far less serious injury in its consequences than may generally be supposed. Surgeons experienced in operations for strangulated hernia are quite familiar with the following facts: that patients operated on *early in the period of strangulation*, in a very large proportion of cases recover with singularly little inconvenience, and with remarkably slight symptoms; but that the fatality attending operations for strangulated hernia is almost entirely to be attributed to mischief occasioned to the intestine *by delay*, or by unnecessary force applied to the hernia in prolonged, sometimes violent, attempts at reduction previous to operation. The simple wound of the peritoneum is generally considered as

by far the most unimportant condition in the treatment of a case of strangulated hernia.

A case of femoral aneurism, under the care of the late Mr. Keate, in St. George's Hospital, was treated by ligature of the external iliac artery. The peritoneum was accidentally wounded in the operation, to the extent of about an inch. The patient died a few days after the operation, from causes unconnected with this wound. On examination, the wound was found perfectly united; there was not the slightest evidence of peritonitis, or any effusion of fluid within the cavity of the peritoneum.

A simple wound of the peritoneum need not, therefore, be considered as necessarily productive of fatal peritonitis.

The management of a *large wound* in a protruded portion of intestine is quite a different matter from that of a small wound, and the treatment should also be regulated somewhat by the manner in which the intestine is wounded; viz., whether it be cut more or less across, or whether it be entirely divided. "Before adverting to the consequences of wounds inflicted on the exposed intestine," observes Mr. Travers, "it will be necessary to describe certain appearances, which the wounds exhibit, depending upon the action of the bowel. If a gut be punctured, the elasticity of the peritoneum and the contraction of the muscular fibres open the wound, and the villous or mucous coat forms a sort of hernial protrusion, and obliterates the aperture. If an incised wound be made, the edges are drawn asunder and reverted, so that the mucous coat is elevated in the form of a fleshy lip. If the section be transverse, the lip is broad and bulbous, and acquires tumefaction and redness from the contraction of the circular fibres behind it, which produces relatively to the everted portion the appearance of a cervix. If the incision is according to the length of the cylinder the lip is narrow, and the contraction of the adjacent longitudinal, resisting that of the circular fibres, gives the orifice an oval form."[1] We have no choice of treatment when called to a case of a large wound of the intestine; we should close that wound by suture, and return the bowel into the abdomen as quickly as possible. Some little fancy may be exercised in the choice of suture; but *that* is a minor consideration. "I am not aware," says Mr. Travers, "that any formal directions are required for the operation of sewing up a wound of the intestine. Let a small round sewing-needle, armed with a silk thread, be passed near to the lines formed at the bases of the everted lips. The thread is to be carried, at short regular distances, through the whole extent of the wound; the operator being mindful that an equal portion of the edges is included in each stitch. When the suture is finished let the thread be securely fastened, and cut close to the knot."[1] [In the use of sutures in closing wounds of the intestines, it is a matter of importance that the parts embraced by the ligature shall be tightly constricted,—that the ligature be so deeply imbedded in the tissue as to allow the peritoneum to close over it, and also to secure the rapid death of the tissues embraced, that the ligature may rapidly find its way into the lumen of the gut, be detached and discharged, and not linger as a source of irritation to the mucous membrane. It is desirable also that as much of the ligature as possible shall be within the lumen of the gut, and as little on the peritoneal covering. This may be accomplished by an interrupted suture applied as follows: Pass the needle from the mucous surface in making the first half of the stitch, and from the serous surface in the last half of the stitch; the two ends to be tied will then be on the inner side, and when tightly tied the ends may be pushed through the wound into the cavity of the bowel.] The main object in view, in the application of the sutures, is the most perfect adaptation of the wounded intestine, so that extravasation of its contents may be effectually prevented. The intestine is to be returned to its natural bed, without any measures being adopted to retain the wounded portion near the external wound. *No ligature should be used for such a purpose.* The treatment of the internal wound is thus independent and quite distinct from that of the external one. The latter, on the replacement of the bowel, is to be managed as if no other injury had occurred.

When the entire cylinder of the bowel is divided, the case is far more serious. A vast number of experiments have been made to establish some definite rule in the treatment of such extensive injuries: any relation of these experiments would occupy too much of our space without any beneficial return; and it is therefore necessary merely to confine our remarks to the most practical observations that bear upon this subject. Mr. Travers states that the retraction ensuing upon direct division of the intestine "renders this injury irreparable." But there are on record some few cases of complete division of the bowel in which recovery is stated to have taken place. The condition of the extremities of the divided portion, will, in some measure, resemble the margins of a small wound in the intes-

[1] Travers On Injuries of Intestines, p. 85.

[1] Mr. Travers has proved, by experiment, that "the absolute contact of the everted surfaces" is requisite to avoid the risk of abdominal effusion.

tine, viz., the mucous membrane will protrude from the open extremities and fold over the peritoneal surface; so that, when the divided portions are brought together, the two opposed surfaces will consist of two surfaces of mucous membrane touching each other. This latter fact has originated numerous theories respecting the treatment of these injuries, and has led to the performance of innumerable experiments on animals, with a view to ascertain the most effectual means by which this *supposed* difficulty might be overcome: viz., that two mucous surfaces in contact with each other could not unite. The results of these experiments have been that some surgeons have recommended sutures to be applied in such a manner that the mucous surfaces should be turned in, and the serous surfaces alone brought into contact. Others have invaginated the upper into the lower portion of the divided bowel; and various other devices have been advocated to insure contact and union. But the main fact has, in most of these speculations, been entirely lost sight of: viz., that if the margins of each end of the divided bowel are but accurately adjusted to each other, and maintained in perfect apposition by sutures (whether the mucous or serous surfaces be made to touch), the divided portions are united at first, *not* by any act of union *between* the surfaces in contact, but by the effusion of fibrin around the once separated but now approximated and contiguous extremities; and thus does this fibrin not only maintain their conjunction, but it also, by adhesions, fixes the injured portion of the bowel to the adjacent surfaces of peritoneum, either visceral or parietal. When the surgeon finds that a wound of the bowel amounts to entire division of the gut, he may at once fix the divided portions in contact with each other with silk sutures, and then return the intestine into the abdomen. Or else he should lose no time in securing the edges of the wound of the intestine to the margin of the external one, so as to facilitate the formation of adhesions between the adjacent surfaces of both, and to prevent the possibility of any feculent contents escaping into the peritoneal cavity. In complete division of the bowel, such treatment is to be preferred. Its effect is necessarily the establishment of an artificial anus in the first instance.[1] The following points should guide us in the choice between these two methods of dealing with an entire division of the intestine: that, if the division be caused by a clean sharp instrument, the extremities may be brought entirely together with sutures; but if the separation be the result of an irregular lacerated wound, as from gunshot, etc., then we should not hesitate to fix the edges to the external wound, and risk the chance of an artificial anus.

If the divided extremities be brought together by sutures, and replaced in the abdomen, the injured portion of bowel need not be retained by ligature at the external wound, for, as a general rule, the one has been found to remain in contact with the other; and when perfect occlusion of the cut surfaces has not occurred, but some escape of the contents of the bowel taken place, that effusion has passed through the external wound; the adhesions within have prevented internal extravasation.

Let us now consider by what steps reparation occurs in a wound of the intestine, subsequent to the application of ligature or sutures. The results of all recorded experiments prove *this:* that there rapidly takes place an effusion of fibrin on the surface of the peritoneum around the wound. This effused fibrin soon agglutinates the wounded portion of intestine to the adjacent surface of peritoneum, and thus covers in the suture, and shuts it out from the general cavity of the peritoneum. The ligature or suture applied to the wound in the mean time has commenced to destroy the small portion of bowel which is surrounded by the silk—that portion of the gut is either killed by the ligature, or all the coats ulcerate through, in consequence of the action of the suture. The death of the part in the first, or the ulceration of the part in the second instance, are processes which travel from without *towards* the *interior* of the bowel. *Exteriorly*, either process is limited by the effused lymph. *Internally*, there is nothing to stay either one or the other. Either is continued until the death of the part, or the act of destruction (ulceration) is completed. The mucous lining of the intestine is included with the other coats in the grasp of the silk ligature or suture; and when the last remaining portion of the wall has been cut through by the action of one or the other, the knotted silk drops into the bowel and passes away with its contents.

Thus much, therefore, is evident: first, that, soon after the application of a ligature or suture to any portion of intestine, fibrin is effused on its surface, and the ligature becomes thus shut out from the peritoneal sac; secondly, the ligature equally soon commences to destroy that portion of bowel which is surrounded by the silk; thirdly, that, as the mucous membrane (forming one of the layers of that portion) dies, or ulcerates, it opens inwards a path of escape for the ligature, which is only complete when each coat of the bit of intestine is entirely cut through;

[1] The treatment of artificial anus forms a separate section.

and, fourthly, that this path opens *into* the bowel, not *from* it.

Mr. Travers tied a ligature round the duodenum of a dog, so as completely to obstruct the intestine. This was returned into the abdomen, and the wound closed. On the fifth day, the dog passed a copious stool; and he recovered entirely from all effects of the ligature. He was killed on the fifteenth day. The wound of the duodenum, produced by the ligature, was entirely closed. Omentum was adherent to the surface at the part to which the ligature had been applied. The gut, when laid open, was marked by a transverse fissure at the seat of ligature. The ligature had passed away entirely.[1] The wound is thus closed; the ligature has escaped; and the injured portion of bowel is adherent to the abdominal wall, or some adjacent viscera. What has become of the everted edges of the mucous membrane? Are the surfaces united, face to face, or so inverted as to allow the wounded intestine to unite at its edges? Mr. Travers was evidently not satisfied on this point. He observes, "The opposed villous surfaces, so far as my observation goes, neither adhere nor become consolidated by granulation; so that the interstice marking the division, internally, is probably never obliterated."

Observation of wounds in mucous membranes of other parts does not allow the author to agree with these remarks; nor does Mr. Travers appear to have had *positive* evidence to enable him to decide unhesitatingly that such union *could* not, or *did* not, occur. Drs. Gross and Petrequin arrived at the conclusion that union *does* occur between the edges of the divided mucous membrane, and that the former position of the gap, after a time, is only indicated by a line of cicatrix.

The treatment subsequent to the replacement of the injured intestine should be similar to that sketched out in our observations on wounds of the abdomen. Punctures or wounds of the intestine must always be considered as very dangerous in their character, and are very frequently fatal in their result; and an entire division of the bowel is generally fatal.

Wounds of the Stomach, with protrusion, are much more rare than wounds of the intestines. The treatment of wounds of the stomach should be guided by principles similar to those which apply to wounds of intestines: though if the wound be large, it would be best to secure its edges to the external one, rather than apply sutures and simply return the protruded portion into the abdomen. A large wound so treated would, for a time at least, be followed by gastric fistula.

[1] Travers On Injuries of Intestines, p. 99.

Wounds of the viscera which occur in penetrating wounds through the abdominal wall, may be said to be decidedly more formidable than those just considered.

Punctured wounds of the stomach or intestines, if small, are not necessarily followed by effusion. If the stomach be empty, in all probability effusion will not take place. Inflammation rapidly causes the aperture to adhere to some adjacent surface of peritoneum, and thus occludes the opening on the peritoneal surface. If the stomach be full, extravasation of its contents into the cavity of the peritoneum is apt to occur; but this complication need not necessarily take place, for vomiting rapidly supervenes upon wounds of the stomach, and soon empties it of its contents; blood would be mixed with the fluid thrown up, or large quantities of blood alone vomited. With escape of the contents into the peritoneum, there would follow all the most severe symptoms described in cases of rupture of the stomach. If the wound be across the lesser or greater curvature, very abundant hemorrhage will be present, either into the stomach, or into the peritoneal sac. The danger in a wound of the stomach is greatly lessened when its contents are observed to escape externally; and though, in such cases, life hangs by a thread, instances have occurred of such wounds terminating in gastric fistulæ, from union of the margins of the internal with the external opening; so that the patient survived the accident.

Dr. Marcet has several times succeeded in establishing gastric fistulæ, by opening the abdomen of dogs, and drawing the surface of the stomach to the wound, and there fixing the coats with sutures; an opening then made into the stomach allowed a silver tube to be introduced and made fast in the opening. The care with which the operation is performed in a great measure influences the recovery of the animal; it is requisite not to disturb the parts much, and not to allow the escape of the least portion of the contents of the stomach into the peritoneum, otherwise the animal dies. Dr. Marcet states, that it requires a strong, hardy animal to recover from this operation; and generally, when recovery has taken place, the animal does not appear to be worse for the fistula: escape of the gastric fluid is controlled by a cork inserted into the silver tube. The latter is fastened into the wound, most effectually, by an ingenious method adopted by Dr. Marcet. Two dogs, in each of whose stomachs a fistula had been formed, survived more than twelve months, and appeared healthy and in good condition.

It will always be difficult to determine whether the stomach is implicated in a penetrating wound, unless there be escape of

the contents through the external wound, or there be blood vomited. The treatment, therefore, must depend on the symptoms. No interference should be permitted with the external wound, if the contents are passing through it. The stomach should be kept empty, and the patient nourished entirely by enemata of beef tea or soup. If there be no evidence of escape of the contents, but if it be suspected that the latter have passed into the peritoneum, as evidenced by the severity of pain and other symptoms, no treatment is available to save life; and, in such a case, we have only to endeavor to mitigate suffering.

Punctured wounds of the intestines from penetration of the abdominal wall by a sharp instrument, are not so serious as similar wounds of the stomach. Such small wounds do not generally permit extravasation of the contents, as the opening is soon plugged by the mucous membrane. But larger wounds are much more fatal, unless the internal wound be in apposition with the external one, so that the contents of the bowel may escape externally. In such a case, the wound should not be interfered with. An artificial anus for a time may be established, and so far immediate danger is lessened, if not removed. It is impossible to determine what portion of bowel may have been wounded in a penetrating wound of the belly, or whether several portions are not implicated in the injury. The external wound is no guide to us in this respect. If the wound of the intestine be very small, there may occur but very slight symptoms to indicate its existence; but if large, or if there be several wounds, then blood will probably be observed in the motions; and pain, vomiting, and other severe symptoms, will soon indicate the alarming character of the local damage. As a rule, wounds of the small intestine are more serious, *cæteris paribus*, than wounds of the large. In a wound of the latter, the escape of the contents externally is more probable, and more ready, on account of the movements of the bowel being much limited, and the aperture consequently more fixed. The escape of fecal matter into the peritoneum depends much on the state of the bowel; even with a large wound in an empty intestine, Mr. Travers found that extravasation did not necessarily occur at the time of the injury. With regard to the treatment of wounds of the intestine within the abdomen, whether punctured, or incised, or lacerated (gunshot), we need say little more than that great attention is to be paid to the external wound. Any hope of recovery rests in the chances that, if the wound of the intestine be small, no escape of contents will have occurred; or if the wound be large, that the escape will be external. If the first condition be suspected, we need only simply dress the external wound. If the second be manifest, the external wound *must* be left open,—it is the safety-valve of life in such an injury,—and its premature closure might most unexpectedly and rapidly cause the death of the patient.

[Dr. Dugas, of Georgia, has proposed in case of wounds of the intestine with hemorrhage or fecal extravasation, to enlarge the external wound, search for the bleeding point, ligate the vessel and sponge out the abdominal cavity.

Dr. Dugas[1] has summarized the proceeding as follows:

1. "Induce anæsthesia.
2. "Lay open the abdomen along the linea alba, freely enough to make a thorough inspection of the parts contained.
3. "Ligate all bleeding vessels as far as possible.
4. "Examine carefully the whole length of the alimentary canal, in order to detect any wounds, and to stitch them. If the intestinal wound be ragged, it should be trimmed down to a straight edge.
5. "In gunshot wounds, reduce the channels of entrance as well as of exit through the abdominal walls to the form of incised wounds, so that these may be closed and left to adhere by first intention. In some cases it may be found necessary for this purpose to remove the uneven track by a double elliptic incision.
6. "Cleanse the wounds and peritoneum of all extraneous materials, and close the abdominal walls with suitable sutures and adhesive plasters.
7. "Finally, control the peristaltic action with opium, and administer such nourishment as will leave least fecal residuum, as milk, eggs, etc.

"As supplementary to these suggestions it may not be out of place to add that for anæsthesia I would prefer ether, as being less enervating and safer than chloroform; and that, for stitching the intestines, animal ligatures, of catgut or violin-strings, wet with an antiseptic solution, should be preferred.

"These principles have been most successfully carried out by the writer and others in cases in which the wounded intestines have protruded, and yet we have allowed other cases to die simply because the abdominal wound has not been sufficiently large to permit the bowels to come into view."]

Wounds of the liver, spleen, and kidney are dangerous, in proportion to the amount of hemorrhage, rather than from other circumstances. As it would be impossible to determine the fact of injury of either

[1] Transactions of the International Medical Congress of Philadelphia, 1876.]

the liver or spleen in a punctured wound, we need not enter further into the question, beyond stating thus much, that, if *hemorrhage* be not fatal, there is no reason the patient should not recover. Hemorrhage will be indicated by collapse, etc.

Wounds of the kidney or bladder will be suspected from blood in the urine. When the latter viscus is injured, as a rule, the case will prove fatal if urine has entered the sac of the peritoneum. See INJURIES OF THE PELVIS.

In concluding his remarks on this portion of the subject, which embraces the consideration of wounds of the viscera, the effects of those wounds, and their treatment, the author ventures to hope that the reader will derive some assistance from the following general summary—a kind of index of results attendant upon these injuries:

1. That a rupture of stomach or intestine, *without external wound*, is a fatal lesion; more fatal than when lesion of either viscus occurs *with external wound*.

2. That when rupture of liver or spleen is fatal, death is generally the result of hemorrhage. Rupture of the gall-bladder is always fatal.

3. That when rupture of the kidney proves fatal, death, when occurring early, is the result of hemorrhage; when occurring later, is the result of extravasation of urine.

4. That recovery from rupture of the liver, spleen, or kidney, is not improbable nor uncommon.

5. That a wound of the peritoneum, without bruise or laceration of tissues, is by no means necessarily fatal.

6. That a protrusion of intestine, or portion of other viscera, if the protruded part be not bruised, nor long exposed, need not necessarily prove fatal.

7. That a wound of protruded intestine or stomach, if small, should be secured by ligature—if large, by sutures; and the protruded viscus returned into the abdomen. The former lesion may terminate in recovery; "but wounds amounting to direct division of the canal are irreparable,"[1] unless artificial anus be established.

8. That a punctured wound of viscera is more dangerous than a wound with protrusion—less dangerous than rupture without external wound; that the danger is in proportion to the size of the internal wound; and that an artificial anus offers the best prospect of recovery when the wound is extensive.

FISTULA OF THE STOMACH.

Hennen, in his work on Military Surgery, observes, that "wounds of the stomach are extremely dangerous, though not mortal;" and he adds, that, according to M. Percy's observations, only four or five out of twenty recover. We have already alluded to the prospect of recovery after a wound of the stomach. Recovery may, in the first instance, occur from immediate blocking up of the internal wound, and union of the external one by first intention; or recovery may be qualified to this extent, that the two wounds become soon united to each other by their margins, but leave an opening through the walls of the stomach and the external parts. An escape of the contents of the stomach takes place through this opening, which may continue stationary for an indefinite time; such an opening constitutes a *gastric fistula*—fistula ventriculi externa; and we now propose to consider its conditions and treatment.

That the occurrence of a gastric fistula, or its persistence, is not incompatible with life, or even health, is a fact so satisfactorily authenticated, that it requires no confirmation on our part to establish it. We shall have to refer to cases which afford ample and conclusive evidence, not only of the formation, but of the duration of these fistulæ over many years. A fistula of the stomach occurs on the escape of its contents externally, through a lacerated or incised or punctured wound, after the internal and external wounds have become blended by their margins into one opening; or the fistula may be the result of ulceration of the stomach, followed by adhesion of the opposed peritoneal surfaces, and ultimate perforation of the abdominal wall; or the consequence of a foreign body making its way through the visceral and abdominal parietes; or the result of abscess; or the effect of malignant ulceration.

When the wound, which allows the escape of fluid and food from the stomach, has become clean and healthy, granulation slowly produces a continuous smooth cicatrix between the outer skin and inner mucous surface of the stomach. This is, however, generally rather a tedious process, the cicatrization being frequently interrupted by painful excoriation and ulceration, caused by the excessively irritating quality of the fluids constantly oozing out. But for a time the opening gradually contracts. If originally small, it may close in the course of a few weeks; if not small, it will probably remain open many months; it may remain fistulous for many years.

The first difficulty with which the surgeon most probably will have to contend, will be the escape of the food; the second, will be the prolapse of the mucous membrane. The escape of the food will depend, in amount, on the size of the opening; the loss may be so great, that sustenance be-

[1] Travers, p. 133.

comes a question of moment; and then recourse must be had to nourishing enemata. It is never desirable to plug the fistula to prevent escape of food, for the action of the plug is invariably to dilate the opening. A compress over the opening is the best application for the purpose of moderating the escape; and sometimes this treatment will succeed almost entirely in effecting the desired object.

The prolapse of the mucous membrane will depend very much on the size of the opening, as also somewhat on the part of the stomach implicated in the fistula. If the opening be in the upper portion of the large extremity, the prolapse will probably be but slight; whereas if the opening be towards the lower part, or pyloric extremity, the protrusion will be more troublesome. However, prolapse of the mucous membrane does not generally offer any difficulty in treatment; it is usually readily returned, but requires slight pressure to keep it from escaping through the fistula.

The following well-known case so well illustrates the points above alluded to, that we cannot help introducing it shortly, for that purpose. Alexis St. Martin, aged eighteen, was wounded by a musket on the left side, when about a yard from the muzzle. The shot blew off the integuments and muscles, to the size of the hand, fractured and carried away the anterior half of the sixth rib, fractured the fifth rib, lacerated the lower part of the left lung and the diaphragm, and perforated the stomach. On the sloughs separating, a perforation large enough to admit the middle finger was observed in the stomach (besides other injuries, which do not bear on this question). *For seventeen days everything swallowed passed out through the wound;* and the patient was kept alive chiefly by nourishing injections. At every dressing of the wound, the contents of the stomach flowed out; its coats frequently became everted, or protruded so far as to equal in size a hen's egg, but were easily returned. After the fourth week the lad's health was quite restored. For some months the food could be retained only by wearing a compress and bandage; then a small fold or doubling of the villous coat began to appear, which gradually increased till it filled the aperture and acted as a valve, while it admitted of being pushed back by the finger from without. The wound was inflicted in June, 1822, and St. Martin was alive in March, 1833. The orifice of the wound was then in the same state as in 1824, being about two inches and a half in circumference. When the stomach was entirely empty, the valve was generally forced out through the orifice, together with a portion of the mucous membrane equal in bulk to a hen's egg. After he had slept for a few hours on the left side, the protruded portion became so much larger as to spread over the neighboring integument five or six inches in circumference, and fairly exhibited the natural rugæ, villous membrane, and mucous coat lining the gastric cavity.[1]

In the Med.-Chir. Trans., vol. xli., a case is related by Dr. Murchison, of a woman aged thirty-four, in whom a fistula was occasioned by the continued pressure of a copper coin over the epigastric region; ulceration was set up; and the pressure. constantly applied to the surface of the ulcer, at last effected a communication from without into the cavity of the stomach. Dr. Murchison has added to the particulars of this case a short table of cases of gastric fistulæ, many of them the result of disease commencing from within.

The treatment of a gastric fistula should, in the early days of its occurrence, be most simple. The parts should be kept scrupulously clean, and the compress and bandage and other dressings frequently changed; lint, moistened with tepid water, is the simplest and most cleanly dressing, and should be used as soon as the wound has commenced to granulate; and as long as there is any tendency to contraction nature should be permitted to pursue her course unmolested. Frequently, such fistulæ will close without our interference.

When all further prospect of closure is at an end, when contraction of the orifice of the fistula appears to have been carried to the utmost, and the fistula indicates that, without some surgical assistance, it may remain patulous for the period of the patient's life, then it becomes the duty of the surgeon to endeavor to assist in the closure of the orifice; otherwise the fistula will last for years. Richerand mentions one extending over a period of nine years. In Haller's Dissertations two cases are recorded, one by Etmuller, in which the fistula continued open for ten years; another by Wenker, in which it remained patulous for twenty-seven years. Under such prospects the presence of a gastric fistula becomes a grave evil, and all practicable efforts should be made to relieve the patient. The prospect of closure held out by a plastic operation is such, that we may attempt by repeated operations to close the orifice, even should the first prove unsuccessful. Dr. Middeldorpff[1] has related a case, in which he lately succeeded in almost entirely closing a gastric fistula (apparently the result of some ulcerative process in the stomach), which had existed some five years. A flap of skin was brought up from the lower extremity of the opening, and fixed to its edges by sutures. The whole of the surfaces united, with the exception of a point the size of half a pin's head. As this fistula happened to be situated between the cartilages of the sixth and seventh ribs on the left side, it was in

[1] For further interesting particulars of this case, we must refer our readers to Dr. Beaumont's Experiments and Observations on the Gastric Juice, and the Physiology of Digestion.

[1] Brit. and For. Med.-Chir. Rev., October, 1860, p. 545, from the Wiener Wochenschrift, Nos. 3-6.

an unfavorable position for contraction, and in an equally unfavorable part for the success of any attempts made to close it. The almost complete success of Dr. Middeldorpff is very encouraging, under the circumstances of the case he has related; and should lead us to anticipate complete relief from a similar operation, were the fistula situated below the cartilages of the ribs, and in a situation in which the tissues yield more readily. Sometimes one or two sinuses burrow round an abdominal fistula; should such exist they should be laid open before the attempt is made to close the principal artificial aperture.

Fistulæ of the gall-bladder may be the result of abscess caused by the presence of a gall-stone. Such cases are very rare, nor do they require much more than a passing notice. Before such a fistula can form, the patient must have had pretty marked evidence of previous mischief in the neighborhood of the liver and gall-bladder, with constitutional disturbance of no slight character. The treatment, as far as the surgeon is concerned, should be to give exit to matter as soon as local evidence of its collection is in any degree marked, or its existence suspected. Should a gall-stone be lodged in the abscess, or present at the opening, some degree of caution is necessary in interfering with it; but the sooner it can be removed without risk, the earlier will be the relief afforded to the patient, and the sooner will the parts commence to recover. There may remain a fistula with bile escaping from it for some time, but unless there be some marked reason for surgical interference, it were better to leave the parts to contract of themselves.

Artificial Anus.

Artificial anus "generally results from loss of substance consequent on mortification of the bowel in strangulated hernia, but may be the consequence of penetrating wounds, or of ulceration of the canal from internal or external causes."[1] Whether artificial anus be the result of accident or disease or operation, the conditions which the opening may assume, or the treatment to be adopted for its relief, in either case cannot vary to any great extent. We therefore propose to consider the evil under both aspects.

As in lesions of the stomach, so in fistulous apertures of the intestine, there may be a small or large permanent opening, established by the union of the sides of the internal wound with the circumference of the wound in the abdominal parietes. But the size of the fistulous orifice, through which escape of feculent fluid takes place, will depend entirely on the amount of destruction of the intestinal wall, not at all on the original size of the external wound. In proportion to the loss of the former, there will be experienced a difficulty in closing the latter, and in proportion to the distance of the common orifice from the pylorus will the chance of immediately saving or of prolonging life be increased. For the purpose of considering the general features of an artificial anus in its early condition, we will assume that, whether the fistula be the result of wound, or mortified bowel, or other cause, the orifice in the bowel has become fixed to the margins of the external aperture; that all sloughs caused by injury or disease have become separated; and that there is, at the opening, a continuous surface from the integument without to the bowel within. What characteristics may we expect to find about such an opening? Usually the aperture will be more or less round, but it may be oblong and irregular. The smaller it is, as a rule, the more circular will be its shape. The margin will seldom present a smooth or healed condition, but will often be somewhat puckered, and more often excoriated and bleeding. The skin surrounding the aperture will generally be much irritated, sometimes quite sore, and often very sensitive or exquisitely painful; all which is the result of the irritating matters escaping from the gut and running over the integuments round the fistula. As the orifice of the fistula contracts, the surrounding skin is thrown into slight ridges, the furrows between which become sometimes deeply ulcerated. The condition of the orifice itself will depend much on the size of the opening; if small, the mucous membrane will generally be observed at the bottom of the orifice, and a constant oozing of feculent matter and intestinal mucus will persist as long as the orifice remains.

If the orifice is large, some amount of prolapse will constantly occur through the fistula; but when the intestine retains its proper position within the abdomen, from the posterior wall of the fistula will be observed a fold of membrane—its thin edge projecting towards the outlet. If the destruction of the bowel has been extensive; for instance, if the bowel has been divided, and the divided extremities have become attached to the external wound; or if three-fourths of the wall of the intestine has been lost by slough, or shot away, and an artificial anus has been formed, then we shall be able to observe distinctly the upper and lower orifices of the bowel, and between them the fold of mucous membrane will be seen projecting almost to the level of the external outlet; in fact, so as to form a distinct and prominent partition which extends from behind forwards, between the

[1] Lawrence, On Hernia, p. 379.

openings of the upper and lower portions of the gut. In proportion to the projection of this fold into the wound, so is the obstruction to the passage of the contents from one opening to the other. The fold may even, and often does, project sufficiently to lap over the lower opening, and then will conduct the whole of the contents of the upper division of the bowel directly outwards through the artificial anus. The fold, to which we have now drawn attention, constitutes an important feature in the ultimate condition and in the treatment of artificial anus; to this fact we shall refer presently.

Such, then, are the general external characteristics of artificial anus. We have now to examine the conditions, within the abdomen, of the portion of bowel implicated in the opening. If we trace a convolution of the upper portion of the intestine towards such an aperture, on approaching the latter, the bowel will be observed, within the last few inches, to form an angle more or less acute with the portion of intestine which forms the commencement of the lower division. According to the amount of destruction of the bowel, and the prominence of the fold of mucous membrane within the wound, will be the acuteness of the internal angle; and if the angle be very acute, in consequence of extensive destruction, the portions of bowel forming the angle will lie more or less side by side, or sometimes across each other, as they approach the fistula. The serous surfaces of these opposed portions are not generally adherent to each other. Intestinal convolutions may dip down between them, and even push forwards a serous sac into the artificial opening. This is an important fact, viz., that the mass of intestine within the abdomen is only protected externally, at the artificial opening, by the thickness of the wall of the adherent bowel. The serous surface of the intestine, where the latter is adherent to the abdominal wall, is continuous with the parietal peritoneum all round the false opening; for the two serous surfaces, parietal and visceral, have become adherent to each other, either previous to the sloughing of the bowel in a hernia, or subsequent to the wound of the intestine in an injury. The adhesions, which unite the intestinal to the external orifice, occur first on the peritoneal face of each opening, and are at first slight, but subsequently become more firm as they become vitalized. But the extent of such adhesions is never broad, nor capable of offering much resistance to the pressure of the viscera within. Sir W. Lawrence justly observes, "The abdominal cavity is protected at the margin of the opening by a feeble barrier; the extent of the adhesions being only from half a line to a line, sometimes, but rarely, reaching to half an inch."[1] As the membrane covering the bowel attached to the orifice is thus continuous with the parietal peritoneum within, so the membrane lining the bowel is continuous with the cuticle which surrounds the artificial anus without.

Such, then, are the general and early conditions usually found in a case of artificial anus; certain variations may be met with, dependent on locality. In an artificial anus, the result of an accidental wound of the large intestine, or the consequence of an opening made into the colon in the lumbar region for the relief of obstructed bowel, the probability is, that no fold of mucous membrane will exist, such as is observed when any considerable portion of the small intestine has been destroyed. When the opening is high up and implicates the jejunum, the fluids which escape are less offensive than when the opening exists in the lower part of the intestine. When the opening is in the large bowel, the discharge often consists of hard feculent masses, and is always of the character of that passed naturally from the rectum. Within also, when the large bowel is implicated, there need be little disturbance of the natural position of the bowel; there need be no angle formed by the upper and lower portions of the bowel fixed at the aperture; and there need be no adhesions of the serous surfaces to secure the wounded intestine to the abdominal wall, as the bowel may have been opened external to the serous sac.

Certain changes will occur in an artificial anus, as time passes. If the opening was originally small in the intestine, the external orifice will gradually contract, the escape of the contents will diminish in proportion to the contraction, and in some few weeks or months, the aperture may close. If the aperture in the intestine was originally large, the artificial opening will gradually become less, up to a certain point, and then remain stationary in size. The edges will often become thick and callous, and will also occasionally become puckered inwards; at the same time, the fold of membrane which projects from within, becomes gradually directed away from the orifice which leads into the upper portion of the bowel; for the stream of feculent matter acts constantly against the corresponding surface of this projection, and inclines it towards the orifice of the lower portion, sometimes so as to close it completely, and thus effectively prevents the passage of fæces from the upper into the lower portion of the bowel. In proportion to the extent and projection forwards of this fold, will the passage of feculent fluid

[1] Lawrence, On Hernia, p. 380.

or food across the area of the artificial anus, and through the lower portion of the intestinal canal, be diminished; the fold acts as a dam across the natural passage, and directs the stream through the new aperture, to be discharged externally. And as the facility of communication from one to the other becomes less, so the orifice of the lower portion contracts, while that of the upper portion often becomes dilated and thickened. As the artificial orifice is not guarded by a sphincter muscle, the escape of the contents is constant, and is beyond the control of all voluntary efforts or desire. The patient's health will become much deteriorated if the small intestine is open far above the ileo-cæcal valve; nutrition is then but imperfectly carried on. The patient suffers greatly from the excoriation caused by the acridity of the discharge, the constant moisture of the skin, and the frequent necessity to cleanse the wound; so that with a slight attack of diarrhœa, or other exhausting ailment, one in such a condition rapidly sinks. "The prospect of regaining and preserving health and strength," observes Sir W. Lawrence, "when the continuity of the intestine cannot be restored, depends entirely on the situation of the unnatural opening; is greater in proportion as that is nearer to the inferior end of the canal, and smaller as it approximates to the stomach."

Fig. 190.

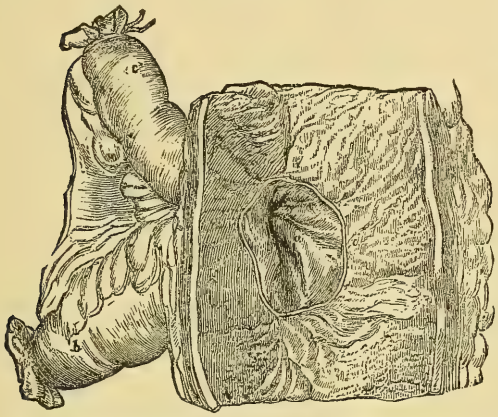


Fig. 190. Artificial anus, showing the angle between the two portions of intestine. The lower portion of gut in the drawing is the one nearer the stomach, and is larger than the other. (Museum of Royal College of Surgeons, No. 1384.)

One of the most marked effects of an artificial anus, whenever the feculent fluids escape entirely through it, is that the lower portion of the bowel, *i. e.*, all below the aperture, becomes contracted; and in time, so much so as hardly to be recognizable as the intestine of an adult. The tube is, however, rarely obliterated. Dupuytren mentions a case which occurred in the Hospital of Val-de-Grâce, in Paris, observed by M. Begin, and in which the lower portion of the bowel was obliterated, and formed a solid cord. The portion of intestine forming the artificial anus was the transverse colon. The patient was eighty years of age when he died, and he had suffered from artificial anus for forty years. The lower portion of the rectum was not quite obliterated, but next to the artificial orifice, no trace of canal was to be found.[1]

Fig. 191.

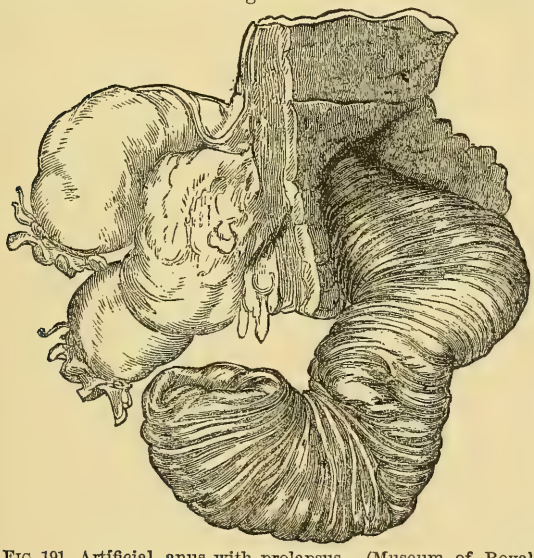


Fig. 191. Artificial anus with prolapsus. (Museum of Royal College of Surgeons, No. 1386.)

In an artificial anus there is a constant tendency towards prolapsus of the bowel (Fig. 191). There may also occur a hernial protrusion behind or through the wall of the adherent intestine, or between it and the external wound (Fig. 192). This is not frequent. Prolapsus usually takes place through the orifice of the upper portion, and is a common occurrence to a slight extent. Generally the protruded bowel is readily returned, and can then be retained by gentle pressure secured by a bandage or truss. But prolapsus may be very extensive, and may even prove fatal.

[1] Dictionnaire de Méd. et de Chir. pratiques, tom. iii., p. 133.

A patient operated on by the author, in the autumn of 1859, for strangulated femoral hernia, was found, when the sac was opened, to have mortification of the greater portion of the circumference of a piece of small intestine. The bowel was cut open where dead, and the protruded intestine left in the wound. An artificial anus was thus established; and though the patient was greatly reduced, and extremely ill for many days subsequently, she recovered sufficiently to quit the hospital about three months after the operation. The artificial anus was then rather more contracted than at first, but almost all the fæces passed externally through the opening. She gradually gained strength, and recovered sufficiently to be able to do a little work. About six months after she left the hospital, one afternoon while lifting some furniture when cleaning her room, she felt something suddenly wrong in the region of the artificial anus, and immediately experienced great pain. She was only able to get on to the bed, and being quite alone, was unable to procure assistance. She now perceived that there was a large protrusion at the artificial anus. In the evening her husband returned home, but so drunk that he could not be made to understand the urgency of her sufferings, and would not consent to any medical advice being procured. The poor woman passed the night in great suffering, and in the morning the husband, having returned to his senses, called Dr. Martyn, of Brompton, to see her. Hearing the particulars of her history, Dr. Martyn asked the author to visit her. A large mass of prolapsed bowel, some three feet in length, was found lying external to the artificial opening. The mucous membrane was dark-colored and almost black from congestion, and blood was oozing from its surface generally. The protruded portion of bowel was thrown into several convolutions, was greatly distended and much solidified, and excessively tender when touched. She was admitted into St. George's Hospital, where, after consultation with Mr. Cutler the author attempted the reduction of this really frightful-looking mass of prolapsed bowel. While attempts at reduction were being made with extreme care and much gentleness, a quantity of intestine (covered with peritoneum) was observed to escape suddenly from the abdomen, by the side of the bowel already prolapsed and covered with mucous membrane. A double complication now existed. The exact peculiarities of this complication will it is hoped be understood by reference to the accompanying illustration; but, to render the case more clear, its various stages and conditions are shortly recapitulated. Previous to the occurrence of the prolapsus, the original openings in the intestine and the abdominal wall were adherent to each other by their opposed margins, so that one common opening, the artificial anus, was the result; the visceral and parietal peritoneum being continuous with each other around the internal aspect of the opening. Through this common opening a portion of the upper bowel became prolapsed, and projected externally. This projection was the mass covered with mucous membrane, which was seen in the first instance. The pressure exerted by the protrusion of so large a mass of bowel on the margins of the artificial anus, caused the adhesions between the two original wounds to give way; consequently the opening in the wall of the bowel was no longer attached to the abdominal opening; and the latter now communicated directly with the interior of the peritoneum. Through this opening, leading into the cavity of the peritoneum, the portion of bowel covered with peritoneum passed out; but there had already escaped, through the same external opening, the prolapsed bowel. The following condition of parts, therefore, was found at the aperture in the abdominal wall:

Several convolutions of bowel protruding externally and without sac. In the walls of one portion of this protruding mass was the opening of the bowel made at the time of the operation for the relief of the hernia: and through this opening projected a large mass of prolapsed bowel; the mucous membrane of which was of a dark-red color and highly congested. So that, side by side, exposed to the air and lying outside the abdominal wall, there was intestine protruding covered by peritoneum, and intestine prolapsed covered by mucous membrane; the two being but portions of one mass of small intestine escaped from the peritoneal cavity, through an artificial outlet at the femoral ring.

The prolapsus was readily reduced, by drawing upon the portion of bowel which had last escaped. The latter was traced to the point where the invagination commenced, and was then gently pulled until the invaginated por-

Fig. 192.

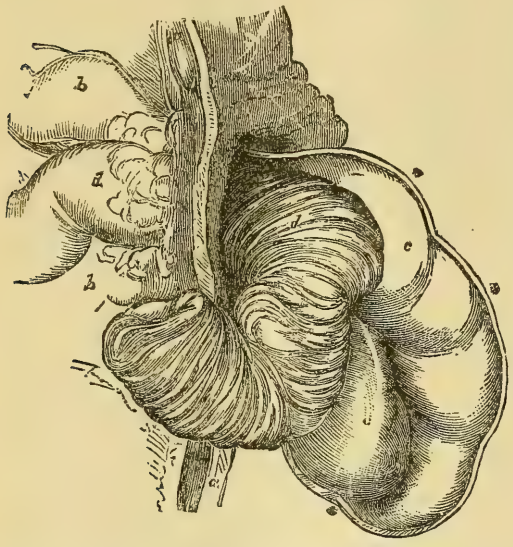


FIG. 192. Artificial anus, with prolapsus and hernia (ideal representation). *a*, The abdominal wall. *b*, The coils of intestine inside the peritoneal cavity, some of which have formed a hernia, and are represented at *c*, external to the abdomen, covered with the peritoneum, which is marked by an asterisk. *d*, One of the two coils forming the artificial anus which is prolapsed, and shows its mucous surface external to the abdominal wall.

tion was entirely unfolded. The intestine was then easily returned into the abdomen, and the original wound of the bowel secured to the margins of the external opening with sutures. The poor woman was so much exhausted by her prolonged sufferings, that she expired the following morning. The portion of intestine below the wound was found very much contracted, and free from feculent matter.

When hernial protrusions occur through an artificial anus, the coverings of the hernia will be solely formed by the coats of the adherent intestine, mucous membrane outside, and peritoneum within; but should the hernial protrusion be other than small, we must anticipate some separation of the adhesions which attach the orifice of the bowel to the abdominal wall, as occurred in the case last described. In such a case, the pressure exerted on the intestine round the orifice would be very considerable, and the protruded sac might even be ruptured from this cause.

The treatment of artificial anus depends much on the features of each case. When the opening is small, we need do little more than require the patient to be kept as clean as the circumstances of the case will permit, and meanwhile endeavor to restrain the escape of fæces or food through the orifice, by the application of gentle pressure. Closure of the opening will frequently occur, in such a case, without any further interference on the part of the surgeon. A young woman, operated on for strangulated femoral hernia, by Mr. Johnson, in St. George's Hospital, recovered with an artificial anus in the left groin. By degrees the opening gradually contracted; once or twice it appeared closed; again opened; and, some eight months after the operation, became entirely healed. A similar case occurred in the practice of the author, though the artificial aperture closed in a much shorter period.

If the opening shows no tendency to close, and the patient objects to operative interference, the inconvenience can be but little mitigated by external measures. Pressure offers the best prospect of regulating somewhat the escape of the fæces. Various arrangements have been adopted to alleviate the distress of the patient; receptacles of different shapes and materials have been so fixed to the body, as to cover in the orifice of the bowel and receive its contents as they pass out. But though much ingenuity has been exercised upon the construction and adaptation of such appliances, at best they have been found of but trifling service. Mr. Lawrence recommends the constant use of a truss to prevent prolapsus; and the author's experience induces him strongly to advocate the importance of this recommendation. A compress of linen placed in the opening, with a larger pad over it, and a truss applied over the whole, will in a great measure restrain the contents, as well as prevent the protrusion of the bowel.

The relief or closure of artificial anus has been attempted by surgical interference. Before alluding to the measures adopted for what is termed *a radical cure*, we must shortly refer again to the condition of an artificial anus which has baffled the surgeon's attempt to close it by pressure. In such a case, the orifice of the upper portion of the bowel will be well marked, and the fold of mucous membrane (*éperon*, as it is termed by French authors) will be more or less prominent. If a finger can be passed into the opening of the upper portion, and another into that of the lower portion of the bowel, and the ends of the fingers be approximated, they will only be separated at these two points by the opposed walls of the intestine; but for an instrument to pass through from one portion of the intestine to the other, the peritoneum would have to be necessarily twice perforated; for usually no adhesions exist between the serous surfaces corresponding to these points. The éperon, or fold, at its *free* margin, consists of two layers of mucous membrane; but immediately behind the free border will be formed of the muscular and serous layers of the bowel.

In order to push back the prominent edge of the éperon, Desault passed a tent of linen three inches in length into the intestine, through an artificial anus in a patient under his care, and covered the opening with a compress and bandage. This tent he proposed to remove twice a day, to allow the evacuation of the fæces; but he found that, after some noise and pain in the bowels, some fluid was discharged through the rectum, and during three following days several motions were passed. The tent was discontinued on the eighth day, and the opening was closed by compress, and supported by a truss. The case quickly recovered. It is stated that nothing had passed through the rectum in this case, from the time of the receipt of the wound which produced the artificial anus, until the treatment alluded to was adopted by Desault, a period of four years. This method of treatment can only be recommended for trial in cases in which the internal angle of the bowel is not very acute, and consequently when the éperon is not very prominent. In fact, in such cases, with proper care and simple pressure, time will most probably insure permanent obliteration of the artificial opening.

It will now be evident that the chief obstacles to the closure of an artificial anus, which defies the usual palliative treatment, arise from the loss of intestinal wall, the

consequent acuteness of the angle at which the portions of the intestine meet at the aperture, and the unavoidable prominence of the éperon or fold—conditions which most effectually interfere with the passage of fæces into the lower division of the bowel. If the serous surfaces of the two portions of the intestine, within a few inches of the opening, were adherent to each other, nothing would appear more justifiable or easier than to divide the éperon some distance inwards, commencing at its free margin; and then this process of treatment would probably be as safe as it would be easy. A direct and free communication between the upper and lower portions of the bowel would be thus immediately established; the éperon would be destroyed; the fæces would flow along the natural channel more readily than escape externally, especially if pressure was applied over the opening. But it has been explained that the éperon is formed merely of a duplication of the mesenteric or attached border of the wounded bowel; the artificial aperture would, in most cases, be situated in some portion of the former free surface. The duplication would therefore consist, within the intestine, of two layers of mucous membrane; within the abdomen, of two layers of serous membrane, and intermediately of the muscular and cellular coats of the bowel. To divide this éperon to a sufficient extent to relieve the obstruction it produces, would necessitate cutting into the cavity of the peritoneum; for we should have to cut through the opposed portions of bowel. Even a further risk would have to be encountered. There might be intestinal convolutions lying between those two surfaces of bowel, which must necessarily be divided in order to secure sufficient increase of space in the canal; therefore an instrument carried across the space occupied by such convolutions might seriously injure any portion of viscera there interposed.

To Dupuytren[1] we are indebted for originating a method of treatment which, perhaps of all others, holds out the prospect of dividing the éperon, with as little amount of risk to life as can possibly be obtained in so formidable an undertaking. But the fact must be fully appreciated, that any interference with this éperon, or projecting fold, must always necessarily be attended by considerable risk of peritonitis, and danger to life.

"Restoration is seldom accomplished by the united efforts of nature and art," writes Dupuytren, "when the loss extends to four-fifths, or to the entire circumference of the intestine, with or without the mesentery, whatever may be the extent of the mischief in length. The destruction of the bowel, the contraction and change of direction in the tube, the projection of the ridge and septum, are here carried to the greatest extent, and constitute an insuperable obstacle to the transmission of the intestinal contents in their natural course. If compression be employed with sufficient exactness to prevent escape of fæces, symptoms of strangulation are produced, such as colic, nausea, vomiting, hiccough."

Dupuytren saw that if, without opening into the cavity of the peritoneum, he could in extreme cases destroy the éperon by any means which would facilitate the passage of fæces in their natural course, the probable result would be the closure of the artificial anus; but that, without the removal of the éperon, there was no prospect of relief. He determined to make the attempt to establish a direct communication between the upper and lower portions of the gut by destroying the septum. After one or two attempts to effect this by pressure and ligature, he ultimately made use of an instrument, which he termed an *entérotome*. By the application of this instrument, he considered that the projecting ridge and septum might be destroyed in a short period. It is here only requisite to state, that this instrument is so constructed that it somewhat resembles a pair of forceps, the blades of which can be separated from each other, or, when adjusted to the septum, can be approximated by the action of a screw, so closely as to be firmly fixed on the part embraced in their grasp. One blade, being grooved, receives the edge of the other, when the instrument is closed; so that any intervening tissue, thus firmly grasped, is so effectually compressed as to be destroyed in a very short time. When it has been decided to use this instrument, "the first step is to find the two openings of the intestine, and to determine accurately the direction taken by the corresponding portions of the canal. Usually this is the longest and most difficult part of the proceeding. The discharge of the contents generally points out to us, without much trouble, the orifice and course of the upper end. But greater difficulty is experienced in discovering the lower. When the position of the openings and the course of the two portions of bowel have been ascertained, one branch of the entérotome is introduced into one end of the bowel, and, according to circumstances, carried to the depth of one or more inches; the other branch is placed to a corresponding depth in the other end."[1] The blades are then adjusted and firmly fixed by the action of

[1] Mémoires de l'Académie de Médecine, tome i., 1828.

[1] Dupuytren, op. cit.

the screw. Dupuytren recommended that the pressure should at once be carried to such an extent as to extinguish circulation and life in the part immediately; and, to prevent circulation being re-established at any point, he advised the pressure to be increased every second day.

The application of the instrument does not usually occasion much pain, according to Dupuytren's statement. The effects of the application will not be completed for

Fig. 193.

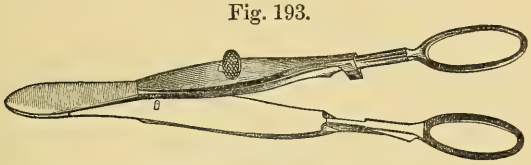


Fig. 193. Gross's enterotome.

seven or eight days; after which the separation of the sloughs, occasioned by the strangulation of the intestinal wall, will allow the instrument to be removed without further trouble, and without the blades being opened. "By the division and loss of substance, the ridge and the double septum, which separate the two ends of the bowel, are destroyed, so as to re-establish the interrupted communication between them, and restore the natural course of the aliment and fæces."[1] This treatment appears simple enough and most rational, when considered merely as a mechanical procedure; but in practice we must not be surprised if its adoption were to prove productive of very severe symptoms in many cases, and even fatal in not a few. In the first instance, when closing the blades of the enterotome, we run the risk of catching between the blades a portion of intestine not implicated in the artificial anus; and if we escape this danger, we have to run great risk of setting up peritonitis, by the action of the instrument on the two surfaces of that membrane inclosed within the blades. Still, on the other hand, it must be remembered that the patient has to submit to a most loathsome condition—great suffering and continued annoyance without any prospect of relief; while in many cases there is also the probability of life being much shortened, from the want of adequate nutrition. The surgeon, in proposing the operation to a patient, can honestly state that it holds out the prospect of permanent benefit, though its performance is attended by considerable risk; but the patient himself should decide whether to submit to it, after having had placed before him all the reasons for and against its adoption.

[Dr. Byrd, of Quincy, Ill., has proposed a method of operating for the closure of artificial anus, as follows: Instead of the enterotome commonly employed for dividing the éperon he uses one like that of Dr. S. D. Gross. (Fig. 193.) Dr. Byrd's instrument is, however, simpler, being made of a steel wire, bent so as to close the blades by its own elasticity.

The fenestrated blades are designed to remove a section from the fold of intestine and thus make the connection more direct between the upper and lower segments of the bowel. Instead of freshening the edges of the fistula by removing a portion of the granulating margin, he makes an incision at the junction of the granulating and cutaneous surfaces, around the fistula, deep enough to allow the granulating and mucous surfaces to be folded into the opening. When this partially separated margin is turned inward, deep sutures are taken three-fourths of an inch from the freshened margin of the skin, passing down to the deepest part of the incision. When the deep sutures are made tight the granulating flaps will be forced inward. The superficial portions of the wound are accurately adjusted by fine points of suture.]

The following are the results which Dupuytren arrived at from his own experience and that of others, in the use of the entérotome:

Of forty-one operations, twenty-one were performed by Dupuytren, and twenty by other surgeons. Three cases terminated fatally; one from supposed fecal effusion; one from peritonitis excited by the operation. Of the remaining thirty-eight, the greater number had no unpleasant symptoms: some had colic, nausea, and vomiting. Fistulæ, more or less extensive, remained in nine; rendering the constant use of a truss necessary. Twenty-nine patients were completely cured, in periods varying from two to six months.

Some doubts have been expressed by M. Jobert[1] respecting the correctness of Dupuytren's conclusions regarding the safety of this operation; and the former recommends that, in the use of the instrument, the pressure should, in the first instance, be gradual, and only increased as the symptoms permit. He has observed all the symptoms of strangulation follow the application of the blades, when applied so firmly as immediately to destroy the life of the part, and states that fatal cases have occurred after such application.

Surgeons have had but little experience

[1] Op. cit.

[1] Traité des Mal. chir. du Canal intest., tom. ii., p. 125.

in the application of the enterotome in this country. Fortunately the cases requiring its use are rare in the present day; but if we are permitted to draw a conclusion respecting the advantages of treatment by the use of the enterotome, and the effects produced by its application, we would most strongly advocate a gradual, rather than a rapid closure of the blades, in any case in which it was considered advisable to employ the instrument.

Foreign Bodies in the Stomach and Intestines.

The introduction, whether accidental or intentional, of foreign bodies into the stomach, is not an uncommon occurrence; their retention in the alimentary canal is generally productive of evil; and therefore the management of such a case is well worthy the utmost consideration of the medical practitioner. The term "foreign body" is applied to a substance which, when introduced into the stomach or bowels, is proof against the rapidly dissolving action of the gastric fluid; such a substance as retains its original size and general configuration while stationary within, or while passing through, the intestinal tube.

Great varieties of foreign bodies have been found in the stomach and intestines after death: and though it may not be necessary here to enumerate all, it will be found desirable, practically, to distinguish certain varieties from others, and so to classify them; for according to their character, consistence, or shape, they act more or less prejudicially on the parts which surround them.

The following classification will embrace sufficiently the varieties most frequently met with:

1. Round and flat bodies, such as money, fruit-stones, bullets, pebbles, calculi, etc. These substances are generally the least dangerous in their effects.

2. Materials which, by accumulation, form large masses; such as hair, string, the husk of the oat, etc. Such substances generally constitute the largest foreign masses met with in the food-tube.

3. Sharp-pointed or cutting bodies; such as pins, fish- or other bones, knives, false teeth, etc. These are generally attended by fatal consequences, if they become lodged in the stomach or intestine.

Foreign bodies may remain in the stomach for a certain period without producing much inconvenience; but generally, when retained, they are attended, sooner or later, by serious, if not fatal consequences. The treatment of a case in which a foreign body has become lodged in the alimentary canal, gastric or intestinal, must therefore be ever a subject of extreme anxiety. If the substance be a piece of money or any other small body, it will be passed, often without much discomfort, in the course of a few days, sometimes within forty-eight hours of having been swallowed. But should the substance be a bone, or other irregular-shaped or uneven mass, it may be some weeks before it escapes through the rectum; and its progress through the tube is often attended by pain, and sometimes much distress and suffering, in passing the external outlet.

The early symptoms, indicative of a foreign body in the stomach, will depend very much on the shape and nature of the mass. If it be a pin, or a fish- or sharp meat-bone, or any steel instrument pointed or uneven, or metallic tooth-plate, the symptoms usually present will be pain referred to the epigastrium—pain sometimes of a very severe character; a sense of weight and discomfort at the stomach; often a desire to vomit, or an actual ejection of the contents of the stomach, and blood, either mixed with the fluid thrown up, or passed in the motions. If the patient is thin and the substance large, it may occasionally be detected through the abdominal wall. When the foreign body is formed by an accumulation of hair or other tissues, introduced into the stomach by degrees from time to time, the symptoms will be chiefly those of severe indigestion, such as a weight and pain in the epigastric region.

The effects of a foreign body passed into the stomach will also differ according to the shape and consistence of the mass. The substance may be slowly propelled into the intestine, and thence escape externally through the natural outlet; or be retained in the intestine, and there produce fatal mischief, or be rejected from the stomach by vomiting. The mass may be retained in the stomach, producing there ulceration and perforation of its coats, and so ultimately fatal peritonitis; or peritonitis may occur as a consequence of partial obstruction, without perforation. The mass rarely remains in the stomach without ultimately producing fatal complications.

The treatment of cases in which foreign bodies have entered the stomach must depend greatly on the nature of the substances forming these bodies, as well as upon their shape.

A lady in attempting to swallow some pills, dislodged her artificial teeth, consisting of two central incisors fixed to a small gold plate. The mass passed at once into the pharynx and œsophagus; and was soon followed by pain referred to the median line, at a point a little above the epigastrium. On attempting to take food, she experienced difficulty in swallowing it; and the greater portion almost immediately returned. Mr. J. Blackstone attended the patient for some days, but as she

did not improve the author was requested to see her. There was still, on the tenth day, much discomfort, inability to swallow without pain, and food could only be taken in a fluid form and in small quantities at a time. These symptoms continued without much alteration till the nineteenth day. As the patient then was no better, but evidently thinner, an œsophagus tube was gently passed down the throat; when approaching the cardiac orifice, the extremity of the instrument came in contact with some resisting, apparently solid, substance. With very slight pressure this appeared to be dislodged, and the tube passed freely on. On its withdrawal the patient expressed herself relieved, and was at once able to swallow with comfort.

In a few days, however, she again began to complain of pain in the pyloric orifice of the stomach; but though the pain persisted without relief, it did not prevent her from partaking of food. In this state she continued till one day she again attempted to swallow some pills, which made her vomit; and she brought up a quantity of fluid from the stomach, and with it the artificial plate and teeth attached, as perfect as the day when swallowed. The mass was fixed nineteen days in the œsophagus; and remained ninety-seven days in the stomach. The longest diameter of the plate was three-quarters of an inch; a sharp point, somewhat hooked, projected on one side; a less sharp one on the other: these no doubt occasioned the arrest of the foreign body at the pyloric orifice. The patient had no bad symptom after the ejection of the plate; and perfectly recovered her usual good health.

In another case, which occurred in the practice of Mr. T. Taylor, of Edinburgh, an artificial plate with six teeth attached was accidentally swallowed; but as the extremities of the plate were rounded, and free from sharp projecting points, and although the longest diameter was one and three-quarters of an inch, it was passed per anum, in three days after.

To Dr. Parr, of New Brighton, the author is indebted for the notes of the following case. A lady awoke in the middle of the night choking; she thrust her finger into her throat and pushed down some hard substance. After some little investigation she discovered the loss of her artificial teeth; which consisted of four teeth attached to a gold plate with two sharp projecting arms to embrace the adjoining teeth. After the nervous dread consequent upon the knowledge of what her stomach contained was overcome, she suffered no inconvenience until upwards of two months, when she complained of pain and tenderness in the region of the head of the colon. Six months from the time she swallowed the teeth they passed by the rectum, bright and clean. The long diameter of the plate was two and a quarter inches, width three-quarters of an inch.

There is nothing more frequently swallowed, and that intentionally, than pieces of money. The swindler in the streets of London, in the habit of passing false coin, when detected in the act, will invariably endeavor to swallow the piece of money intended to have been passed, and will generally succeed in the attempt, even if it be the size of a half-crown. No evil effects occur in such instances. The treatment usually pursued by the man, in his own person, is peculiar and not irrational. He avoids purgative medicine as worse than useless. On the other hand, he has recourse to a constipating diet, and feeds for some days on hard-boiled eggs and cheese, in excess, beyond his usual diet. His theory is, that the more solid and copious the contents of the bowel, the more sure is the piece of money to be caught in the passing feculent matter, and thus will be most readily propelled onwards to the external outlet. It is believed that aperient medicine delays the expulsion of the coin.

An interesting case is recorded in the annual report on the convict prisons for 1868, of a man, who was suddenly seized with vomiting blood, and died almost immediately; a post-mortem examination revealed a half-crown piece lodged in the œsophagus, which had produced ulceration of the tube and perforation of the aorta.

It is a very common occurrence, that a pin placed in the mouth accidentally slips down the pharynx. Not unfrequently this happens with children; and the mother, in her anxiety to do something, immediately doses the little patient with castor-oil; and *then* seeks medical advice. In such an accident, it is far better to avoid purgatives; and rather allow the patient to eat plentifully, so that the foreign body may have the best chance of being carried through the intestinal canal, imbedded in and surrounded by feculent matter. It were better to encourage costiveness than establish relaxation of the bowels.

A sharp-pointed mass retained for a time in the stomach or intestine, may gradually penetrate the walls of the canal, and ultimately escape externally, by perforating the walls of the abdomen. Whenever such a result is indicated by a pain, and swelling and redness of the external parts, the escape of the mass may be hastened by a cautious use of the knife. Previous to the escape of the foreign body, adhesions will have connected the stomach or intestines to some portions of the abdominal wall, and thus the internal wound will be shut out of the peritoneal sac, and the foreign body will be contained in a cavity of its own, between the opening in the bowel and that in the abdominal wall; otherwise, the passage of any substance through the walls of the intestine, into the cavity of the peritoneum, would set up violent if not fatal peritonitis; such as we witness when the bowel is suddenly ruptured.

Needles or pins, when once swallowed, may escape from the intestinal tube, travel through various structures, and subsequently make their exit some distance from the point at which they had passed through

the coats of the bowel. It has been affirmed that persons have swallowed whole packets of needles, and that at various times, and in different parts of the body, separate needles have made their appearance. But it is necessary to receive with some caution the evidence of a patient under such supposed condition. The peculiar impulses of an hysterical mind occasionally induce a female to practice an amount of deception towards the medical attendant, which may induce him, on the first view of the case, to take for granted that which, upon careful investigation, would turn out to be fictitious.

The more globular the mass the greater is the chance of its becoming impacted in the intestinal canal, and producing fatal obstruction of the bowels. Such a mass may pass from the stomach into the duodenum, and make some progress downward; but as the small intestine becomes less in diameter towards the ileo-cæcal valve, so the obstruction to the passage of the foreign body, as it is propelled onwards, increases at every inch of its progress; and if the size or shape be such as to prevent its passage through the lower portion of the small intestine, all the symptoms of complete obstruction soon occur. This form of foreign body sometimes consists of a calculus, escaped from the gall-bladder, through an ulcerated opening communicating with the duodenum. Similar results, *i.e.*, obstruction, have been known to occur from the retention of calculi formed by the matting together of the husks of the oat, these particles being introduced into the stomach in that well-known national food of the North called "oat-cake." Various specimens of calculi thus formed are to be seen in the Museum of the College of Surgeons.

The stomach has sometimes been found to contain large masses of different substances, which have been swallowed by patients little by little, until the accumulation has become so great as to set up local irritation, disturbance of the digestive functions, and fatal peritonitis. In the 35th volume of the Med.-Chir. Trans., p. 65, the following case is recorded: "Mrs. B., in December, 1842, was affected with hæmatemesis, vomiting a washhand-basinful of blood. During the succeeding forty-eight hours she lay in a state of total unconsciousness, the pulse scarcely perceptible. The vomiting did not return, and she slowly recovered." In the autumn of 1845 she complained of frequent sickness, pain in the epigastrium, and in the left groin. "A hard tumor was discovered in the left iliac fossa, which moved freely across the abdomen as she moved from side to side. The size and shape of this tumor were very much like an ordinary placenta, and imparted to the fingers the feeling of being very heavy." Nausea, occasional hæmatemesis, and constipation, were the symptoms most prominent in the progress of this case. In October, 1850, the patient died.

"The stomach contained about a pint of semifluid matter, and felt very like the crop of a fowl; the duodenum resembled a large sausage stuffed with lead. On cutting into the stomach, it was partially filled with some gruel-like fluid, and in the lower half were an immense number of pins, of a peculiar black color, not corroded, varied in size, all bent or broken, many very pointed. The pyloric half of the stomach presented a remarkably thickened condition of the villous coat, being highly vascular, and raised in rugous elevations like the stomach of an ox. The weight of the pins contained in the stomach was *nine ounces*. An incision made into the duodenum *displayed a mass of pins very tightly packed, of various shapes, similar to those found in the stomach, and wholly obstructing the tube*. These weighed *a pound*, as nearly as could be ascertained."

The author was requested by Dr. Blakely Brown to examine the body of a young woman, aged eighteen, who had suffered from pain about a tumor in the epigastric region, and had frequently vomited after meals. She subsequently became sickly; and she appeared childish for her age. After a severe attack of vomiting, and much pain about the tumor, she became collapsed and died.

The cavity of the peritoneum contained several ounces of purulent serum, and the general surface of the intestines afforded evidence of recent peritonitis. On opening the stomach a large mass of hair and string, matted compactly together, was found occupying the greater portion of the cavity, and moulded to the shape of the stomach: a narrowed piece projected into the pyloric end. The hairs were long and black, and were matted together with pieces of string and particles of food. The mass measured when dry six inches in length, three and three-quarters in depth, and two and a half across, but was much larger when first removed from the body. Another mass occupied the lower portion of the duodenum and commencement of the jejunum. This portion of the bowel was considerably dilated. This second mass consisted of a smaller quantity of hair than that removed from the stomach, but of a larger proportion of string. The mass was fourteen inches in length, two and a half in depth, and two and a quarter broad in the thickest part. The specimens are contained in the Museum of St. George's Hospital.[1]

In the fifth volume of the Transactions of the Pathological Society is the record of a case by Dr. Bucknill, in which a man, aged twenty-two, subject to epilepsy and maniacal excitement, died from the effects of peritonitis. "There was found a perforation of the stomach, larger than a shilling, situated at the small curvature of the stomach, with dark-colored and ragged edges. The peritoneum was in a state of universal inflammation. On opening the stomach, there was found a mass, about four pounds in weight, composed entirely of cocoa-nut fibre, with bits of string, etc. The mucous membrane was healthy, except at the seat of ulceration."

Mr. Poland has recorded in his Prize Essay the following case: Jas. R., aged twenty-three, a lunatic, confessed to his attendant to having swallowed the handles of two iron spoons. On

[1] For case and drawing, see Pathological Transactions, 1851–52, p. 327.

examination, apparently in the stomach, there was felt a body of the size of a small egg, and upon deeper pressure the sensation of friction between foreign bodies was elicited. The man subsequently appears to have made some vague statements of having repeatedly swallowed spoon-handles, sand, and pebbles. He made little complaint, but stated that he often suffered from severe pain. He vomited occasionally. One day, about three months after his first confession to the attendant, the patient was seized with sudden severe pain in the abdomen, which continued to increase through the night; and from the effects of this attack he died the following morning.

The cavity of the abdomen was filled with dark greenish fluid and much recent lymph. The stomach was lying in the left hypochondriac region, in rather a vertical position, and was much contracted. About an inch and a half from the pylorus there was a perforation on the anterior surface of the duodenum of the size of a swan-quill. On laying open the stomach and duodenum, "a mass of iron spoon-handles and nails and other articles were seen closely packed together." There were thirty-one entire spoon-handles about five inches long, four half handles, nine nails, half an iron heel of a shoe, one screw, four pebbles, and one button; the weight of the whole mass was 2 lbs. 8 ozs. An entire spoon-handle was found in the duodenum, with the flattened extremity towards the pylorus, opposite the perforation.

Of all the remarkable instances on record of a large number of foreign bodies being swallowed intentionally, there is none to equal in interest one recorded by Dr. Marcet. In this case, a sailor swallowed at different times a number of clasp-knives, some thirty-seven in all. Some of these he passed whole, per anum, at intervals; subsequently he passed some fragments, and once he vomited a knife-handle. A short time before his death a portion of one was felt fixed across the rectum, but gave so much pain on examination that it could not be extracted. He lived ten years after having swallowed the first knife. On examination after death, one blade was found fixed across the rectum, with one extremity projecting into the muscular parietes of the pelvis. A back spring of a knife had transfixed the descending colon opposite the left kidney, and projected into the peritoneal cavity; the spring was four inches and a half long. In the stomach there were between thirty and forty fragments of knives. For the further particulars of this case we must refer the reader to Dr. Marcet's interesting report.[1]

Foreign bodies which pass into the intestine are apt to be obstructed in their progress at the ileo-cæcal valve. Such is frequently the case with small bones, fruit-stones, etc., and occasionally the mass will here set up ulceration, and be followed by abscess in the right iliac region. The common result of such an abscess is general peritonitis, and the patient often soon sinks under the attack; but less frequently the abscess opens externally, the foreign body escapes, or is removed, and the patient recovers after a severe and prolonged illness. Fruit-stones are apt to become lodged in the appendix, and are a frequent source of mischief. Such stones are sometimes carelessly swallowed with fruit in large numbers, and are occasionally retained in the intestines for many months without inconvenience; but are as often the cause of much irritation, and even of troublesome obstruction.

Mr. Clement, of Shrewsbury, operated on a patient suffering from obstruction of the bowels, for the relief of which the ascending colon was opened. The patient was so much relieved by the operation, that at the end of six weeks she was able to walk about. About a week subsequent to this period she was seized with colicky pains, and an obstruction occurred at the bottom of the artificial opening, when suddenly a hard mass was shot out from the artificial anus. This substance "was found to consist of five plum-stones firmly agglutinated to each other. These were followed by sixteen other single plum-stones, and afterwards by a very copious feculent evacuation. On the following day three more stones found an exit, accompanied by two small bones." At different intervals the patient continued to pass plum-stones, the total number collected previous to her death being *one hundred and sixteen.*

Mr. Clement's account of the post-mortem conditions are highly interesting. "The cæcum and the ascending part of the arch of the colon appeared unusual in size, until it was suddenly cut short at the *transverse* part of the arch by the intervention of the most rigid stricture I ever felt. If a piece of whipcord had been firmly tied round this part of the intestine, the occlusion would not have been more complete than was effected by this organic change. The whole remaining portion of the transverse arch of the colon, its descending part, and sigmoid flexure, were collapsed, and formed a thin flaccid tube.

"The stricture itself was of cartilaginous hardness, and the closure of the canal so complete, that it would not admit of the passage even of a bristle. The extent of the stricture was not quite an inch, of a white pearly appearance, perfectly smooth, and had no more apparent vascularity than a tendon.[1] The probability is, that the stricture was the result of effused fibrin, produced by the local irritation, if not ulceration, from the presence of the foreign bodies."

It is still a question open to discussion, and rather to be decided by future experience, how far we may be justified in opening the stomach for the removal of a foreign mass. It must be borne in mind that most of the cases in which a foreign body is retained in the stomach terminate fatally; that life in such cases is limited to a very few years, or perhaps months. The operation of opening the stomach is, on the other hand, a very serious one, perhaps the most serious the surgeon can undertake; but

[1] Med.-Chir. Trans., vol. xii., p. 52.

[1] Med.-Chir. Trans., vol. xxxv., p. 209.

still the cases in which we may contemplate the operation, are so hopeless without surgical interference, that the author is rather inclined to recommend the operation, in such cases as might be considered inevitably fatal if left to themselves. The only recorded successful cases of gastrotomy were those in which the operation was performed on account of the lodgment of a foreign body in the stomach.

[Dr. Pooley of New York has reported ten recoveries out of eleven gastrotomies performed for the removal of foreign bodies.

Three successful cases of gastrotomy for cicatricial stricture of the œsophagus have been reported. 1st, by Dr. Trendelenburg at Bostock, March 8, 1876. A second by M. Verneuil, in Paris, October 28, 1876, and a third by Dr. F. Herff, of San Antonio, Texas, U. S. A., 1879. In the first and third cases the patients masticated the food as usual and forced it into the stomach through a tube passed through the fistulous opening into the stomach. In the second case digestion went on without the aid of saliva.] See the table in the essay on INJURIES OF THE NECK.

Foreign bodies which penetrate the abdominal wall may pass into the intestinal canal, or remain lodged in the cavity of the peritoneum.

Hennen mentions a case in which a man was struck by a musket-ball, on the evening of the 18th June, at Waterloo. The ball penetrated the abdomen a little below the navel. The principal complaint of the patient, subsequent to the receipt of the wound, was incessant straining to stool; and on the sixth day a bullet, enveloped in mucus, was passed through the rectum. Ten weeks after the receipt of the wound the man passed some bits of cloth by stool. A small fistulous opening continued for a short time in the seat of the original wound, and when this had entirely closed, there was a slight hernial protrusion at the cicatrix.[1]

Should an elongated body be thrust into the abdomen, it is always desirable to remove it as soon as possible. The difficulties of such a proceeding will, of course, depend as much on the size and shape of the mass as upon its situation; but any difficulties of removal should not weigh with the surgeon; for if the mass be allowed to remain in the abdominal wall or cavity, more serious results are likely to ensue than if it be at once removed. If allowed to remain in the cavity without an effort being made to remove it, mischief of a serious character is sure to be set up within a short time, and repeated attacks of peritonitis, even if relieved for a period, will destroy the patient sooner or later.

[1] Hennen's Military Surgery, p. 408.

The accidental passage of a cedar pencil into the abdomen, through the urethra of a female, is recorded by Mr. Erichsen. In this case the pencil apparently was pushed through "the posterior wall of the vagina, passed upwards behind the bladder, and then traversed the peritoneal cavity. At this time also the intestine was doubtless perforated, and continued transfixed through two of its coils until the time of extraction, a period of nearly eight months." Repeated attacks of peritonitis occurred after the accident. The patient became much debilitated, and subject to constant vomiting. From the examination made previous to an operation, the pencil was felt to be lodged on the outer and right side of the bladder, vagina, and rectum. An incision was made through the abdominal wall over the point where the pencil could be detected, and it was removed without difficulty. The surface of the pencil was stained in places by the intestinal contents. The pencil was five inches long, and was cut at one end to a sharp point, which was still perfect. The patient only survived the operation four days.[1]

If a foreign body can be distinctly felt in the cavity of the abdomen, having penetrated any portion of the walls, the advantages of early removal will consist in getting rid of an irritating mass, in securing a better prospect of arresting peritonitis, and should the intestine be wounded, in establishing a more certain escape for its contents through the external wound. If the mass be not removed, the repeated attacks of peritonitis will greatly emaciate and reduce the patient, agglutinate the convolutions of intestines together, and very much complicate matters in any future attempt to relieve the patient by operation.

In conclusion, the author would urge the importance of *early action*, when operative interference is indicated or offers a prospect of prolonging life, in all cases in which intestinal obstruction is the cause of threatened danger. He believes that, in many instances, an operation for the relief of obstruction is not successful in consequence of being performed *too late*—that is to say, after peritonitis has commenced. He believes that the wound of the peritoneum, necessary in many operations for the relief of obstruction, is a minor evil; that it is not the operation or its effects that destroy life; but that when a patient suffering from obstruction dies after operation, death is more probably the result of peritonitis produced by the obstruction, than to be attributed to the effects of the knife.

[1] Med.-Chir. Trans., vol. xxxix., p. 15.

INJURIES OF THE LOWER EXTREMITY.

By Carsten Holthouse, Esq.

Revised by Edward T. Caswell, M.D.

The seriousness of a lesion will depend partly on its nature, partly on its extent, and partly on its locality: in the latter respect, injuries of the extremities must rank in importance after those of the head and trunk, and lesions of the upper extremity after those of the lower.

The circumstances which render an injury of the lower extremity more serious than a similar one in the upper, are the greater size of the limb, and its greater distance from the centre of the circulation; so that although the mischief to be repaired is greater, the power to repair it is less: this is strikingly illustrated in lacerated and contused wounds of the foot, and in compound fractures of the leg, which are more prone to terminate in mortification than similar injuries of the hand or forearm. The suspension of the locomotive functions entailed by injuries to this part of the body, must also exert some influence on the circulation, and retard the cure; while the comfort and occupations of a patient are more seriously interfered with than they would be by a corresponding accident to the upper extremity.

Contusions.

These may be considered as they affect the soft parts only; as they affect the bones; or as they affect both soft and hard tissues.

Contusions of the soft parts.—If the skin and subcutaneous tissues are alone bruised, the symptoms and treatment will be the same as in similar injuries to these tissues elsewhere; but when the contusion affects the deeper textures, as the muscles, symptoms may arise resembling those of accidents of a totally different nature. This happens especially when the muscles which surround the large joints of the shoulder or hip are injured, when the accident is liable to be confounded with fracture or dislocation in the neighborhood of those joints.

There can be little doubt that contusions about the hip have not only been mistaken for fracture of the cervix femoris, but have been paraded as examples of bony union having taken place without shortening of the limb. A case recorded in the Gazette des Hôpitaux, tome ix., is probably one of these. The patient was a female, sixty-four years of age, who was supposed to have an intracapsular fracture of the neck of the femur, and was treated for that injury; but was discharged at the end of a month perfectly cured, and without lameness. A somewhat similar case came under my notice about two years ago, in which a like mistake had evidently been made. The patient was a young man, twenty-four years of age, who was stated to have impacted fracture of the neck of the femur; the symptoms immediately after the accident were, it was said, eversion, and shortening of the limb. He was confined to bed for a month, and a Liston's splint kept on; at the end of this time both thighs were of equal length, and perfectly symmetrical, voluntary movements of the limb were perfect, and executed with great force and vigor.

The treatment of these muscular contusions consists in absolute rest of the part in the first instance, and friction of the surface subsequently; nevertheless, as cases of impacted fracture of the cervix femoris have been mistaken for mere contusion, every case of doubt should be treated as a fracture.

Contusions of bone are far more serious than bruises of the soft parts, owing to the possibility of inflammation being set up, with all its consequences—suppuration, caries, necrosis. A blow on the shin may be followed by necrosis of the part struck, or of the entire shaft of the tibia;[1] a fall on the trochanter, though not severe, is often sufficient, in scrofulous children, to set up destructive disease in the hip-joint; while a similar accident happening to the aged is not unfrequently followed by shortening and eversion of the limb, the result probably of the contusion, and subsequent interstitial absorption of the cancellous tissue of the neck of the femur.

Contusions involving all the structures of the limb are usually of so severe a character as to destroy the vitality of several of its structures. In the majority of such cases, amputation is the only remedy; and it should be carried into execution before

[1] See case by author in Path. Soc. Trans., vol. xix., p. 346.

the constitutional irritation, which is sure to follow, has made its appearance.

Sprains and Ruptures of the Muscular and Fibrous Structures.

Of all the joints of the body, none are perhaps more liable to sprains than those of the ankle. This is sufficiently accounted for by the position and functions of this joint, the small size of its articular surfaces, the great weight the astragalus has to support, and the unyielding nature of the lateral ligaments.

The immediate effects of this accident are pain, an inability to bear any weight on the limb, swelling, and afterwards ecchymosis of the soft parts around the joint; all these symptoms varying in degree and extent according to the amount of injury sustained. The remote effects which may follow this accident, if neglected or improperly treated in the first instance, are permanent lameness, from chronic inflammation of the joint; anchylosis, distortion of the foot, weakness of the ankle from relaxation of its ligaments. The lesions which are met with in sprains of the ankle vary from a slight laceration of the connective tissue, smaller bloodvessels, and a few fibres of the lateral ligaments, to a complete tearing through or detachment of the latter, laceration of the muscles and tendons or displacement of these from their sheaths, rent of the synovial membrane, and temporary dislocation of the foot, with or without fracture of one of the malleoli; indeed, the lesions of a severe sprain differ only in degree from those of a dislocation.

Sprains of the ankle are sometimes mistaken for fractures, and the latter for the former; the two injuries may also coexist.

[Mr. Callender draws attention to the fact that in some of these cases a thin film of the malleolus may be detached without any signs of crepitus. (Phil. Med. Times, Oct. 12, 1878, p. 6.)]

Sprains of the knee are by no means uncommon, and are characterized by great swelling from the effusion of fluid within the joint. Sprains of the hip and other joints of the lower extremity are less common than those of the ankle and knee, and are not likely to be mistaken for other accidents. The former may, however, resemble incipient hip-joint disease, and may, indeed, lead to its occurrence; but the error of diagnosis, so far as regards treatment, is not of practical importance.

The treatment of sprains of the lower extremity resolves itself into that for diseases of the joints generally, to which the reader is referred. In all severe sprains of the ankle, and in all cases of doubt as to the exact nature and extent of the injury, it should be treated as a fracture, and the "immovable apparatus," made with starch, is the best application for this particular lesion: the patient may be allowed to go about on crutches with his leg flexed and suspended at a right angle to the thigh as soon as the apparatus is dry. [The editor would in all cases give the preference to some of the various forms of the plaster-of-Paris splint. Ahl's felt splints answer a good purpose in many cases. In the less severe forms of sprain, great benefit will be found to attend the use of the pure-rubber bandage, and this may also find an application in some of the injuries next mentioned.] Laceration or complete rupture of some of the muscles or tendons of the lower limb may take place from violent and sudden contraction or over-stretching of the former, examples of which are most frequently met with in the gastrocnemius and tendo-achillis, the rectus and biceps. A sudden and violent pain in the part, as if struck by a hard body, sometimes accompanied with a sensation of tearing, and with an audible snap, are the symptoms which lead to a suspicion of this injury.

The following is probably an example of this accident. D. B., aged thirty-six, while stooping and exerting all his strength to raise a heavy flagstone, heard a loud snap, and felt a sudden pain about the centre and posterior part of his left thigh; he fell backwards and was unable to rise, and was immediately brought to the Westminster Hospital, where I saw him within one hour of the accident, December 6, 1867, it being supposed to be a fracture of the thigh. All signs of this injury were, however, wanting, except the pain and inability to bear any weight on the limb; he strongly resisted all attempts to flex the thigh, and was incapable of moving it of his own accord. There was no ecchymosis and no numbness of the limb. A long straight splint was applied to the outer side of the limb, which was removed on the 11th, and the patient allowed to go about on crutches. On the 14th he was discharged at his own request. A careful examination of the limb in different positions, failed to detect any injury. There was less muscular resistance on passively flexing the thigh on the pelvis; but pain was still felt at the site of the injury.

A case was under my care a few years ago, in which the right ligamentum patellæ was ruptured from a fall; and two cases of a similar nature are reported by Mr. Shaw in the fifth volume of the Pathological Society's Transactions, p. 241, and were produced by causes which usually lead to fractures of the bone.

For fuller information on these injuries, together with the treatment, see the essay on Affections of the Muscular System.

Wounds.

There are certain circumstances, dependent on locality, which influence all wounds inflicted on this part of the body. Among

those tending to an unfavorable issue, are—1st, the size of the parts wounded, which is more particularly seen in wounds of the bloodvessels and joints; 2dly, the dependent position of the limb, so that even trifling wounds heal less readily than they would do elsewhere; and lastly, the distance of its extreme parts from the centre of the circulation, which renders them, when injured, more prone to become gangrenous. On the contrary, the facility with which the limb may be placed in any position, or encircled by a ligature, for the purpose of either preventing absorption from a poisoned wound, or arresting hemorrhage, and the ease with which most of its vessels may be secured when wounded, are so many circumstances which stand in favorable contrast with wounds inflicted on the head or trunk.

Contused and lacerated wounds of the lower extremity most frequently occur in connection with fractures and gunshot wounds, and are treated of respectively under those heads. When produced by other causes, and unaccompanied by fracture, the only respect in which the treatment would differ from that of similar wounds in other parts of the body, consists in the necessity of absolute rest of the limb during the greater part of the treatment. Incised wounds of the lower extremity, except when made surgically, are not of very frequent occurrence in civil practice; and, when met with, are generally found to have resulted from some accident in the use of the tools employed in certain trades. Thus the knee-joint may be opened by the slipping of a knife in cutting leather or wood placed between the patient's knees; the femoral artery may also be wounded in a like manner;[1] and death has been known to result from a wound of this vessel by the breaking of a wine-bottle held between the thighs while drawing the cork. Ugly flesh-wounds are sometimes produced by the scythe in mowing. None of these, however, require any special treatment which is not laid down under the head of Wounds of Joints and Wounds of Arteries. Punctured wounds of the lower extremity have been observed to be more dangerous when affecting the sole of the foot than either the leg or the thigh; and the danger is increased if the instrument which has caused the wound becomes broken off and buried in the part.

Gross relates the case of a boy, nine years of age, who while running about barefoot, trod upon a chicken-bone, a fragment of which nearly an inch long entered the sole of the foot, lodging deeply in the substance of the flexor muscles, in contact with the metatarsal bones. Pain and swelling followed; but the boy walked about for upwards of a fortnight. Suddenly symptoms of tetanus came on, and though every effort was made, by Professors Gross and Parker, to discover the foreign body, it could not be detected, and death followed a few days afterwards.[1]

Needles, bullets, and other foreign bodies, remain sometimes buried for years in the fleshy parts of the thigh or leg, without causing much inconvenience, and unless their site can be ascertained and they can be conveniently got at, they may be let alone; but when in the neighborhood of a joint, they are apt to excite recurrent attacks of inflammation, and should be removed.

Fractures.

It has been long known that fractures of the limbs are of more frequent occurrence than those of the trunk, but whether the upper or lower limbs are most liable to these accidents is a point not so well determined. Of 1800 fractures treated at the Pennsylvania Hospital from 1715 to 1838, 901 were of the lower extremity, and 572 of the upper. [According to Agnew's Tables (Surgery, vol. i., p. 815), there have been admitted to the Pennsylvania Hospital, from 1830 down to 1874, 8667 fractures, and of these 45 per cent. or 3900 were of the lower extremity, and 44 per cent. or 3813 of the upper. There seems to be some discrepancy with regard to the number of fractures treated in this hospital. In the recent work, "Surgery in the Pennsylvania Hospital," it is stated that 14,012 fractures had been admitted prior to May, 1878. If we take the figures in the text, 1800 fractures to 1838, and Agnew's 8667 from 1830–1873, we have 10,467, leaving, according to the work mentioned, 3545 for the period from January 1874 to May 1878, which is manifestly incorrect; and this notwithstanding the fact that the period from 1830–1837 is counted twice!] Of 1572 fractures at the Calcutta Native Hospital from 1815 to 1837, 681 were of the lower extremity, and 665 of the upper. Of 2328 fractures collected by Malgaigne from the registers of the Hôtel Dieu at Paris, 1006 occurred in the lower extremity, and 850 in the upper;; giving, therefore, out of the total number of 4675 fractures of the extremities treated at these three institutions, a majority of 501 to fractures of the lower.[2] When we take into consideration, however, the fact that many patients with fracture of the upper extremity attend only as casual or out-patients, and so escape registration, it is highly probable that these injuries are quite as numerous,

[1] See a case reported by the writer in the British Medical Journal, 1859, pp. 364, 954.

[1] Gross, System of Surgery, vol. i., p. 373.

[2] Malgaigne, Traité des Fractures et des Luxations, tome i.

if not more so, than the corresponding ones of the lower extremity. This is quite borne out by the statistics of fractures collected by the late Mr. Lonsdale, at the Middlesex Hospital, between the years 1831 and 1837. During this period there were 1901 fractures, treated either as in- or as out-patients, and of this number only 516 were of the lower extremity, and 764 of the upper.[1] These figures probably indicate more correctly than the others the relative proportion of fractures occurring in the two extremities.

Fractures of the Femur.

These fractures, as compared with those of the other bones of the skeleton, stand in the adult, about fifth in the order of frequency; in infancy and childhood about second. Out of 140 fractures noted by M. Colon at the Hospital St. Eugénie in one year, 38 were of the forearm. The next highest numbers were 26 of the femur, and 21 of the clavicle.[2]

Fig. 194.

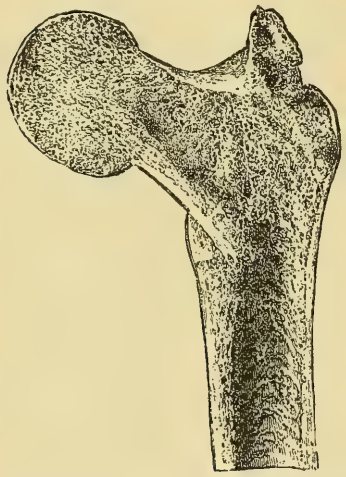
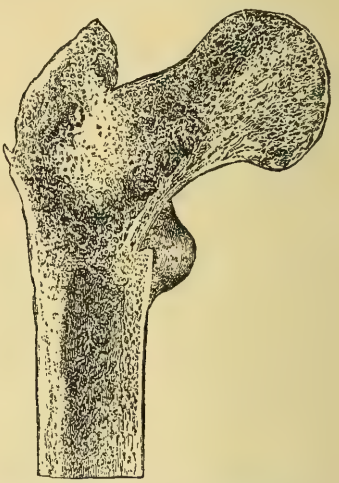


Fig. 195.



FIGS. 194, 195. Two views of an impacted extracapsular fracture of the cervix femoris, the fracture on the upper surface of the neck not being visible. (From the Museum of the Westminster Hospital.)

Fractures of the femur may occur in any part of the bone, and include every variety of fracture; but for convenience of description, I shall first treat of fractures of the upper end of the bone; 2dly, of the shaft; and 3dly, of the lower end.

Fractures of the upper end of the femur.—These are divisible into—1, fractures of the neck of the bone within the capsular ligament; 2, fractures of the neck without the capsule; 3, fractures through the trochanter major; and 4, separation of the epiphysis of the head of the bone, and of the trochanter major.

Intracapsular fractures of the femur.—*Peculiarities:* 1, they nearly always occur in the old; 2, they are more frequent in females; 3, they commonly happen from slight causes; 4, they rarely unite by bone; 5, they usually result in great lameness, and are not unfrequently fatal.

According to Sir A. Cooper, out of 225 cases which he had met with in his practice, only 2 were below the age of 50.[1] Of 28 specimens of this fracture examined by R. W. Smith, 4 were from persons below the age of 50; 9 from 50 to 60, both inclusive; and the ages of the remainder ranged from 65 to 90, also both inclusive.[2] Exceptions are occasionally met with, and have been recorded by Morgagni,[3] who found this fracture in a woman of 40, who had sustained it in her youth; by Stanley,[4] in a lad of 18, and by Hamilton[5] in a girl of 16, and in a man of 25. Neither of the latter were cases of diastasis, for in one "the direction of the fracture was oblique, commencing just at the articulating surface of the head, and ending just within the capsule."

Pathology.—[Under this head we would refer the reader to the admirable article by Professor H. J. Bigelow, on "The True

[1] Lonsdale, Practical Treatise on Fractures.
[2] Holmes, Surgical Treatment of Children's Diseases.

[1] Sir A. Cooper, On Dislocations and Fractures of the Joints, edit. 1842, p. 135.
[2] Fractures and Dislocations, by R.W. Smith, p. 108.
[3] Morgagni, De causis et sedibus morborum, epist. 56, art. 10.
[4] Med.-Chir. Trans., vol. xviii., p. 256.
[5] Hamilton, On Fractures and Dislocations, 6th edit., p. 417.

Neck of the Femur; its Structure and Pathology," in the Boston Med. and Surg. Journ., January 7 and 14, 1875.] Intracapsular fractures of the femur present several varieties, both as regards their situation and direction. The breach of continuity may take place close to the head of the bone, at the point of attachment of the capsular ligament, or at any intermediate part. It may be transverse in direction, more or less oblique, or impacted, the upper end of the lower fragment being usually forced into the cancellous tissue of the upper, or, lastly, there may be a mutual impaction. Much discussion has arisen as to the possibility of partial fractures of the neck occurring; the affirmative being maintained by Colles, Adams and Hamilton, while Robert Smith is "satisfied that the doctrine has not yet been proved to be correct." The integrity of the thin stratum of bone which invests the upper surface of the neck in these alleged partial fractures has been attributed by Adams to its having yielded (without breaking), to the force which fractured the lower surface, while Smith is of opinion that the fracture is not visible because "it traverses the bone exactly where the neck springs from the shaft of the femur." The annexed figures (196 and 197), though from an extracapsular fracture, illustrate this point. Without committing myself to a positive opinion as to whether some of the alleged examples of partial fracture may not have been cases of complete fracture with slight impaction, I entertain no doubt whatever of the possibility and occasional occurrence of incomplete fracture of the neck of the femur, and the cases published by Tournel[1] as long ago as 1837, as well as the more recent one of Dr. Jackson,[2] are incontestable examples of this lesion.

The immediate injury to the soft parts which results from an intracapsular fracture of the femur does not differ from that which occurs in fractures into other joints; the capsular ligament is rarely ruptured, but its cervical reflection is nearly always torn through, either partially or completely, and the amount of separation of the fragments and of the shortening of the limb are, to a certain degree, regulated by the extent of the laceration; there will be also some blood and an increased quantity of synovia poured into the joint. In old-standing cases, the capsular ligament and synovial membrane are usually much thickened and sometimes partially ossified; sometimes all movement between the fractured surfaces is prevented by their close and firm union by fibrous tissue; or the fragments may be only partially united by elongated bands which allow of the free movement of the lower fragment; or there may be no union

Fig. 196.

FIG. 196. False joint after old fracture of the neck of the femur within the capsule. The patient died at the age of ninety-eight, four months after fracture of the shaft of the femur with great displacement. St. George's Hospital Reports, vol. iv. (From St. George's Hospital Museum.)

Fig. 197.

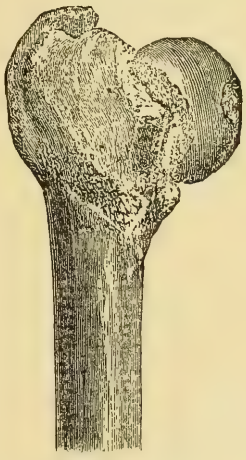


FIG. 197. Bony union of intracapsular fracture of the femur. (From St. George's Hospital Museum.)

of any kind, but a false joint, the broken surface of the upper fragment being hollowed out and eburnated, so as to form a socket in which plays the rounded, smooth, eburnated, and shortened stump of the

[1] Archives gén. de. Méd., 3me série, vol. ii., p. 77.

[2] Bost. Med. and Surg. Journal, vol. iv., p. 351. See also Wilkinson King in Guy's Hospital Reports, Oct., 1844.

lower fragment;[1] or each of the surfaces may be concavo-convex, and so adapted to each other as to admit of a considerable amount of motion between them (FIG. 196). Bony union in this fracture is rare, and by some has been considered impossible; but a sufficient number of undoubted cases have now been brought to light both in Europe and America, to place the fact beyond a doubt.[2] [Packard (Amer. Jour. Med. Sciences, vol. 59, p. 395) records a case of bony union, and also Sands in the Medical Review, vol. 4, p. 187.] Sir A. Cooper, who first pointed out and fully established this fact, does not deny the possibility of bony union; but he asserts that it requires such a combination of favorable circumstances as is very rarely met with; thus it may take place "when the fracture is through the head of the bone, with no separation of the fractured ends; when the bone is broken without its periosteum being torn; or when it is broken obliquely, partly within and partly external to the capsular ligament,"[3] and to these we may add when the fragments are impacted, as was the case in the preparation represented in FIG. 197, or when they can be kept in apposition for a sufficient length of time under any other circumstances. Now although it is the separation of the fragments which undoubtedly forms the chief obstacle to union, there are other causes which conspire to the same result; such as the age and feebleness of the patient, and the small supply of blood to the injured parts. "The head of the bone receives its supply of blood chiefly through the neck and reflected capsule, and when both are severed, the small amount furnished by the round ligament is found to be insufficient." Lastly, the long confinement in one position, which is necessary for bony union, is what many old people are unable to bear.

Causes.—The immediate causes of an intracapsular fracture are frequently very slight; a common one is slipping off the curbstone. The sudden jerk breaks the neck of the bone, and the patient falls to the ground; the fall being, in this case, a consequence of the fracture, and not the cause. The injury may, however, ensue from a fall on the great trochanter, or from a sudden movement of rotation of the body while the limb is prevented moving with it. M. Rodet, by a series of experiments on the os femoris, and on plaster casts of the bone, has arrived at the conclusion that the situation and direction of the fracture may be predicated by a knowledge of the direction in which the force has acted. Thus, a force acting vertically will produce an oblique intracapsular fracture; a force acting from before backwards, a transverse intracapsular fracture; one from behind forwards, a fracture partly within and partly without the capsule; and a force applied transversely, a fracture entirely without the capsule.[1] My experience is confirmatory of the general accuracy of M. Rodet's conclusions.

The remote or predisposing causes of fracture of the cervix femoris, and the connection of the accident with old age, are to be sought for in the impaired nutrition, and the altered chemical composition and direction of the neck of the bone which then prevail. It was formerly supposed that the neck had become more brittle through the preponderance of the earthy material of bone, which was known to be relatively increased in all bones as age advanced; but Mr. Bransby Cooper showed that the quantity of bone-earth in the neck of the thigh-bone of the aged was diminished instead of being increased; thus, the the average quantity in the necks of five middle-aged bones was 50.1 per cent., in

Fig. 198.

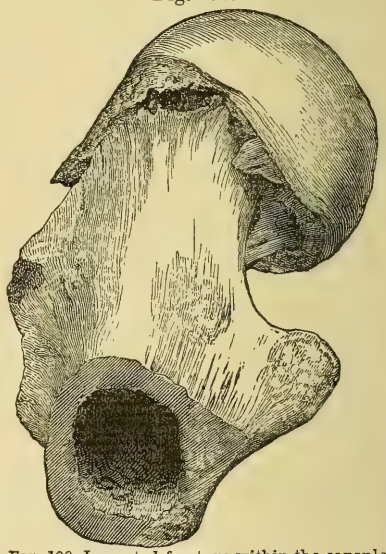


FIG. 198. Impacted fracture within the capsule. (Bigelow.)

[1] See a case by the writer in Path. Soc. Trans., Session 1849-50, p. 252.

[2] For a full account of the various specimens of bony union, real or supposed, see Hamilton, 6th edit., p. 403 et seq. [Also an article by Packard in the Amer. Journal of the Med. Sciences, Oct., 1867. This author suggests that in many of the supposed cases there has been bony union, but of an ordinary extracapsular fracture, the cervical portion of the upper fragment becoming subsequently absorbed.]

[3] Sir A. Cooper, On Dislocations and Fractures of the Joints, edit. 1842, p. 137.

[1] L'Expérience, 14 mars, 1842.

three old bones, 33.5, and in five old bones whose necks had been fractured it was only 23.9 per cent. The shafts of the same bones contained respectively 56.7, 25.5, and 50.1 per cent. of bone-earth.[1] Too much stress has likewise been laid on the altered direction of the neck of the bone,

Fig. 199.

Fig. 199. Horizontal section of neck of femur. (Bigelow.)

which, it was affirmed, became less oblique as age advanced, till it formed a right angle with the shaft. Mr. Canton has shown that this is not correct, and that the obliquity of the neck varies very slightly, the few cases in which it has become horizontal being altogether exceptional; the cortex, however, is always thinner, and the cancelli larger, and frequently filled with an oily fat.[2] It is chiefly, then, to the change of nutrition, senile atrophy, with sometimes well-marked fatty degeneration, that must be attributed the greater frequency of fracture of the cervix femoris at this period.

Symptoms.—The symptoms of an intracapsular fracture ["The sooner the old classification 'intra and extracapsular fracture' is abandoned, the better it will be for science, for diagnosis, and for treatment."—Bigelow, sup. cit., p. 930] of the femur may be summarized as follows: Deformity and loss of power of the limb, crepitus, swelling, and pain.

1. *Deformity.*—This consists of an unnatural prominence of the hip, a fulness of the groin, and a shortening and rotation outwards of the limb; and it is produced by the drawing upwards and rotation outwards of the lower fragment; while the fulness of the groin is partly owing to the broken neck of the femur projecting against the front of the capsule, and partly to effusion within and without the joint. The amount of shortening varies in recent cases from about a quarter of an inch to an inch, [Dr. L. A. Stimson reported a case to the New York Pathological Society where the shortening was *two inches* at the end of seven weeks.—New York Medical Record, March 29, 1879, p. 307], and where there is no impaction it can be overcome by making extension. When it is very trifling in the first instance, it may be owing to a temporary paralysis of the muscles from contusion, or to impaction of the fragments, or to the direction of the fracture being such as to oppose the ascent of the lower fragment. It sometimes happens that there is no shortening at first, but that this symptom makes its appearance gradually or suddenly, some days and even weeks after the accident.

Sir Benjamin Brodie dissected a case in which the cervix was obliquely broken, and in which the upper part of the bone prevented the ascent of the lower. Mr. Stanley also relates the following case: "A man aged sixty was knocked down in the street; he complained of pain in the hip, but there was neither shortening nor eversion of the limb, and its several motions could be executed with perfect freedom and power. A fracture was not suspected; the patient, therefore, was merely confined to his bed. In the fifth week from the date of the accident he died from another cause. No trace of injury was found in the parts about the hip-joint, but small effusions of blood, apparently not recent, were discovered beneath the synovial and fibrous membrane, covering the neck of the femur, also beneath the synovial membrane covering the ligamentum teres. The head and neck of the bone were sawed through their middle, and in each portion a dark line, evidently occasioned by the effusion of blood, was seen extending through the bone at the base of the neck. A fracture was discovered extending along this line; but the broken surfaces were in contact, and the synovial and fibrous membrane covering the neck of the bone was uninjured. In this case," Mr. Stanley very pertinently remarks, "if an attempt had been made to walk at the end of two or even three weeks from the accident, a separation of the fractured surfaces, and consequent shortening of the limb, would have been the result."[1]

[1] Guy's Hosp. Reports, 1845, 2d ser., vol. iii.
[2] Canton, Surgical and Pathological Observations, p. 33.

[1] Medico-Chirurgical Transactions, vol. xiii., p. 511.

The sudden occurrence of shortening, then, some time after the accident, must be ascribed to the displacement of the fragments, consequent on some movements of the limb which have torn through the hitherto uninjured periosteum of the neck, or unlocked the serrations of the fractured surfaces, or converted a partial into a complete fracture; while the gradual shortening of the limb is owing to the gradual absorption of the neck of the bone.

The eversion of the limb, which is often spoken of as eversion of the foot, is really a rotation outwards of the whole limb, so that it rests on its outer surface. This position is given to it by the powerful external rotator muscles of the thigh, aided, no doubt, by the natural inclination of the limb to gravitate in the same direction. [The view of the text as to the cause of eversion has been disputed by Mr. Owen, in a paper read before the Brit. Med. Assoc. at its annual meeting, in 1879. He attributes it to the effort of the limb to seek a stable equilibrium, the support of the neck having been removed. "The limb tumbled into the position of eversion, and muscular action had nothing to do with its position." His experiments seemed to prove that his conclusion was well founded. Med. Record, vol. 16, p. 305.] The continued eversion which sometimes persists after all muscular resistance has been suspended by the action of anæsthetics, can only be accounted for by the interlocking of the broken extremities of the fractured bone. The occasional occurrence of rotation of the limb inwards may be owing to the fracture having taken place while the limb was in a position of extreme inversion, the fragments having become at the same moment so locked together, as to counteract the action of the external rotator muscles. That the fixation of the limb in inversion is not due to the muscles, is proved by the following fact recorded by R. Smith: if extension be made, so as to remove the deformity and restore the length of the limb, "as soon as the extending force ceases to act, though the limb is again shortened, the foot will be found to remain everted."[1]

2. *Loss of power in the limb.*—When a person has fractured his cervix femoris by a fall, or has fallen in consequence of the fracture, he is usually unable to rise, and should he succeed in doing so, he again falls. There are, however, some notable exceptions, in which patients have not only risen from the ground, but walked after the accident. These peculiarities are difficult to account for; some have attempted to explain them on the supposition of an interlocking of the fragments, others of impaction; and others, again, of the resistance offered by the uninjured periosteum of the neck of the bone; but against all these hypotheses must be placed this fact, that loss of power of the limb sometimes exists without displacement of the fragments, and a considerable amount of power has been observed with displacement. Usually, the want of voluntary power over the limb is complete, and passive movements are attended with pain and difficulty.

3. *Crepitus.*—This is a symptom which is by no means easily evoked, and its absence does not prove the non-existence of fracture, though its presence is conclusive in its favor. There are several circumstances which may prevent its being felt; one of these is the drawing up of the lower fragment; hence, Sir A. Cooper directs the limb to be first drawn down, and then rotated. But this will not always bring the fractured surfaces together, for the trochanteric fragment may catch on the acetabular one, and push it before it; or the fragments may be impacted and thus move together with the rotation of the limb; or the muscles may strongly resist the efforts of the surgeon to produce crepitus. "One thing," observes Hamilton, "we ought never to forget, namely, that by extraordinary efforts to obtain a crepitus we may lacerate the capsule, or produce a displacement of the fragments which we never can remedy, and which without such unwarrantable manipulation might never have occurred."

[Bigelow says: "Apart from dislocation, the main object of examination is to decide, with reference to treatment, whether a fracture is loose or impacted." "Prolonged and active flexion and rotation of the hip, in search of positive signs, is more than superfluous." "The most useless and damaging examination is that by quick and persistent rotation, and by flexion of the thigh, as far as a right angle." The points to be determined are: "1st. The degree of shortening. 2d. Whether the shaft rotates through an arc, or on its axis." loc. citat.]

4. *Swelling and pain.*—There is rarely much swelling in this accident, and only a moderate amount of pain, while the limb is at rest; but all movements, especially those of rotation, are attended with considerable suffering. The pain is most felt in the groin and behind the trochanter, and is increased by pressure in these situations.

Fractures of the cervix femoris external to the capsular ligament.—There are three principal types of extracapsular fracture of the femur, depending chiefly on the degree and direction of the force which produced them. In the first and rarest type, the bone is separated into two fragments only, by a fracture which passes through

[1] R. W. Smith, op. cit., p. 25.

the neck of the bone obliquely at its base, and is bounded above and below by the two trochanters, and anteriorly and posteriorly by the inter-trochanteric lines, with which it is parallel. The fracture may, however, be more horizontal in direction, in which case it will pass through the trochanter major, which will thus be separated into two portions—the upper remaining with the neck of the femur, and the lower with the shaft of that bone. Here too may be placed those oblique fractures of the neck of the femur which have been described by Sir A. Cooper as being partly within and partly without the capsular ligament.

In the second type of fracture, which is, perhaps, the most common, the bone is divided into three fragments: the first formed by the head and neck; the second by the greater part of the trochanter major; and the third by the shaft of the bone and a small portion of the trochanter.[1]

[Bigelow's classification of these fractures seems the most simple:

I. Impacted Fractures: 1st. Posterior impacted fracture of the base of the cervix, "the most common of the fractures of the neck of the thigh bone." Shortening and eversion slight.

2d. Impacted fracture of the head of the femur, "rare."

3d. Impacted fracture of the whole base of the cervix with inversion.

II. Unimpacted Fractures: 1st. Fracture of the small part of the cervix. "Much shortening, marked eversion, and the rotation of the shaft upon its axis, instead of through an arc."

2d. Comminuted fracture of the trochanters and shaft. Loc. citat.]

The fracture which separates this process from the other fragments usually begins near the centre of the summit of the great trochanter, passes downwards and inwards, and terminates either above or below, or passes directly through the lesser trochanter. In the third type there is more or less comminution of the trochanteric fragment, and not unfrequently a detachment of the trochanter minor.

Robert Smith expresses his belief that all extracapsular fractures are in the first instance impacted, and that all impacted fractures are necessarily accompanied by a fracture traversing some part of the trochanteric region. This is doubtless true of the majority of extracapsular fractures, but there are some exceptions, as in the specimen referred to by Hamilton in Dr. Mütter's collection, where the neck, having been broken close to the inter-trochanteric lines, has apparently slid down upon the shaft about one inch, at which point it is firmly united by bone. So, again, in those specimens of very slight impaction, which

Fig. 200.

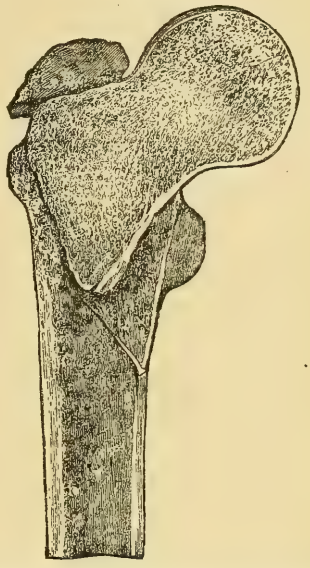


Fig. 200. Extracapsular impacted fracture of cervix femoris with separation of the trochanter. (From the Museum of Westminster Hospital.)

Fig. 201.

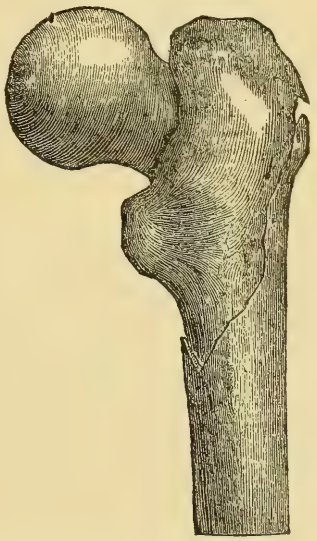


Fig. 201. Posterior view of the same fracture. (From the Museum of Westminster Hospital.)

have been considered by some as examples of partial fracture,[1] no trace of anything like a crack or fissure is to be discovered on

[1] See a very philosophical account of these extracapsular fractures by Dr. Alex. Ogston, in the Medical Times and Gazette, May 15, 1869, p. 516.

[1] See p. 931.

the trochanter. There is a rare variety of extracapsular fracture occasionally met with, in which the lower fragment penetrates a short distance into the upper.

These extracapsular fractures present a remarkable contrast to the intracapsular in their subsequent progress, inasmuch as bony union is the rule instead of the exception; nevertheless, it is a slow process, and the consolidation of the trochanters to the shaft takes place long before that of the opposed surfaces of the fractured neck and of the shaft. The great exuberance of ossific deposit, which frequently takes place in the neighborhood of the trochanters, is supposed to have relation to the comminution and separation of the fragments of these processes.

Causes.—The most common cause of the fracture is a fall from a height, or with great violence, on the trochanter major; this first breaks the neck of the bone, which is then driven into the cancellated tissue between the trochanters, and acts like a wedge in splitting, or even detaching entirely, one or both of these processes. The distance to which the neck of the femur is driven into the cancelli of the shaft, as well as the angle which it forms with the latter, varies in accordance with the violence and direction of the applied force.

"If the force has not been very great, the neck of the femur remains wedged in between the trochanters, and one or both of these processes are split off from the shaft; but if the fibrous structures before alluded to (which invest the whole of the trochanteric region) have not been injured, these broken portions of the trochanters are still held firmly in their places, and the impacted cervix does not become loosened; but if the force has been considerable, the impulse prolonged, the bone in a state of senile atrophy, or if, as frequently happens, the patient in endeavoring to rise falls a second time, then, under these circumstances, the trochanters are not only broken from the shaft of the femur, but are so far displaced and separated from their connection with the soft parts, that the cavity or socket, as it were, into which the superior fragment has been received, is destroyed. The impacted cervix, thus set free, no longer opposes the ascent of the inferior fragment, and the case then presents the characters of the ordinary extracapsular fracture, with great shortening of the limb."[1]

Symptoms.—The symptoms of this accident very closely resemble those of an intracapsular fracture. In both there is shortening and rotation outwards of the limb, with more or less loss of power, alteration in the position of the great trochanter (which is nearer the iliac crest and more posterior than natural), occasional crepitus, swelling and pain. At the same time it must be obvious from the foregoing remarks, that the symptoms will vary somewhat in accordance with the impaction or non-impaction, or degree and angle of impaction, of the fragments. It may be stated generally, that the more complete the impaction (using the term strictly in the sense of fixation), the less obvious will be the signs of fracture, and the more liable the injury to be mistaken for one of a different nature; especially will this be the case where the impaction is slight, and the neck deviates but little from its natural angle. On the contrary, in proportion to the separation of the fragments, so will all the symptoms of a fracture of the neck of the bone be more marked, and the nature of the injury less doubtful. Thus the limb may be shortened, from an inch and a half to two inches or more, but can be drawn down to the same length as the other; the rotation outwards will be greater, the crepitus more manifest, the detached trochanteric fragment more displaced, the pain and swelling greater, with sometimes visible bruising of the soft parts about the hip and upper part of the thigh, and complete helplessness of the whole limb. In complete impaction, the shortening of the limb varies from a quarter of an inch to an inch, and cannot be diminished by traction; the eversion is usually less than in non-impacted fracture, and often very slight. Crepitus cannot be elicited by rotating the limb, the head of the bone can be made to move freely in the acetabulum, and the trochanter moves with it, though on a shorter arc. This process is also nearer to the crest of the ilium, and the limb in general lacks that appearance of helplessness which is seen in the other varieties of this accident.

Inversion of the limb, which has been already alluded to as a very rare occurrence in intracapsular fracture, is met with occasionally in fractures without the capsule. In the dissection of these cases it has been observed that the inferior fragment is always in front of the superior; but this is evidently merely the effect, and not the cause, of the inversion. It has also been observed that the direction of the fracture has been such as to detach the posterior part of the great trochanter, and the whole of the lesser trochanter, with their muscles, either as a separate fragment, or as a part of the acetabular fragment—thus cutting off the influence of these muscles from the limb. This has been considered sufficient to account for the symptom in question, but against this assumption must be placed the notable facts, that inversion of the limb has been met with where there has been no separation of the trochanters, and that it sometimes occurs, as already stated, in intracapsular fracture. I concur, therefore, in opinion with Professor Smith, that the influence of the muscles in producing inversion is but secondary, the lower frag-

[1] R. W. Smith, On Fractures and Dislocations, p. 17.

ment being probably thrown by the violence which produced the fracture into a position favorable for the action of the internal rotators. The chief interest attaching to these cases is in a diagnostic point of view, as they are apt to be mistaken for dislocation (see DISLOCATIONS OF THE HIP).

Diagnosis. — The accidents which are most liable to be confounded with fractures of the neck of the femur, are certain fractures of the pelvis—dislocations of the head of the femur upon the pubes—and severe contusion of the hip; while among diseases may be named chronic rheumatic arthritis, absorption of the neck of the thigh-bone, and paralysis. The particular lesions of the pelvis which most nearly resemble fractures of the cervix femoris are fractures of the acetabulum. The bottom of this cavity may be driven into the pelvis, together with the head of the femur; or a portion of its margin may be broken off, so as to allow of the escape of the head of the femur upon the ilium; or lastly, it may be broken without having its fragments displaced. Each of these fractures gives rise to symptoms which, in one case, may resemble a dislocation of the femur; in another, a fracture of the neck of that bone.

Fig. 202.

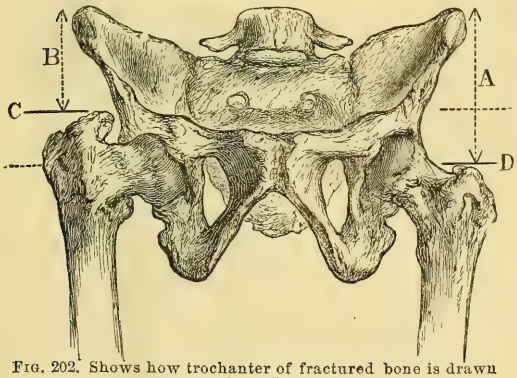


FIG. 202. Shows how trochanter of fractured bone is drawn upwards. (Bryant.)

In the two first there is, in fact, a real dislocation, consequent on the fracture; and it is this complication which renders the true nature of these injuries oftentimes so obscure. Thus there will be shortening of the limb, with inversion or eversion, as the case may be; more frequently the former, and so more nearly resembling a dislocation; but then there will be crepitus, the power of restoring the length of the limb by traction, and the return of the shortening when this is discontinued—all which are characteristic of a fracture. In the fractures of the acetabulum without displacement, the symptoms likewise very closely simulate those of a fracture of the neck of the femur, the absence of shortening of the limb and of crepitus being the only difference; and these symptoms, we

Fig. 203.

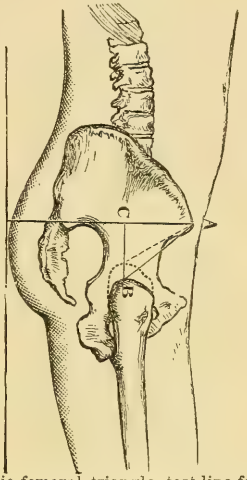


FIG. 203. Ilio-femoral triangle, test line for fracture or shortening. (Bryant.)

have seen, are not always present in this injury. The diagnosis, then, of these several injuries, is by no means easy, though not impossible; and to this we may sometimes be guided by the history of the accident, the age of the patient, and the mixed character of the symptoms. [Mr. Thomas Bryant (Lancet, January 22, 1876), draws attention to the value of the ilio-femoral triangle in the diagnosis of injuries of the hip joint, Phil. Med. Times, April 1, 1876, p. 333 (FIGS. 202 and 203). Shortening of the line CB, as compared with that on the sound side is, he claims, a certain indication of fracture of the neck of the femur.] Practically, perhaps, a mistake of diagnosis is of no great moment, as the treatment is nearly the same for all of these accidents, and it may be observed that the real nature of some of them was only discovered after death.

The symptoms by which a dislocation of the head of the femur upon the pubes may be distinguished from the fracture in question, will be pointed out when treating of that dislocation. A severe contusion of the hip more nearly resembles a fracture than would at first sight be imagined; thus, there may be pain, swelling, ecchymosis, eversion of the limb, with loss of power, and altered position of the great trochanter; and, though crepitus and shortening are wanting, we have seen that these symptoms are sometimes wanting in frac-

ture. In all injuries of this ambiguous character, time and rest eventually clear away doubt; still, as prolonged uncertainty is undesirable, chloroform [ether] should be administered, and a careful examination made while the patient is under its influence. Should a fracture exist, crepitus may perhaps be elicited, and on the recovery of the patient from the anæsthetic, the limb will probably be found to have become shortened; on the contrary, should the limb preserve its normal length, should its movements be found perfect, and unaccompanied by crepitus, we may infer the non-existence of fracture.

Chronic rheumatic arthritis gives rise to symptoms which very closely resemble those of a fracture of the cervix femoris, as exemplified in the following case: "A woman of advanced age was admitted into the Richmond Hospital, having sustained an injury of the hip from a fall upon the trochanter. On examination (the patient having been placed in the horizontal posture), the affected limb was found to be one inch shorter than the sound one; the foot was everted; flexing the thigh upon the abdomen caused considerable pain; and the patient was unable to raise the heel from the bed. From these symptoms it was suspected that the neck of the femur had been broken; upon further examination, however, it was found impossible to produce crepitus, or to restore the limb to its natural length by extension; hence it became evident that the case was one either of impacted fracture of the neck of the femur, or of contusion of a joint previously the seat of chronic rheumatism. Upon being questioned, the woman stated that she had for a long period suffered from pain and stiffness in the hip-joint; that the pain was more distressing in wet weather and towards evening, but was relieved by a night's

Fig. 204.

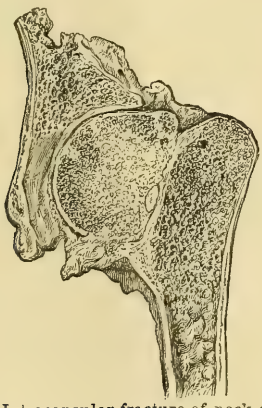


Fig. 204. Intracapsular fracture of neck of thigh-bone, absorption of neck of bone. (Bryant.)

rest; that she had gradually become lame, and had been for some time obliged to make use of a stick when walking. The case was therefore supposed to be one of contusion of the hip-joint combined with chronic rheumatism, and the event proved the correctness of the diagnosis."[1]

The change of form which the head and neck of the bone undergo in these cases is

Fig. 205.

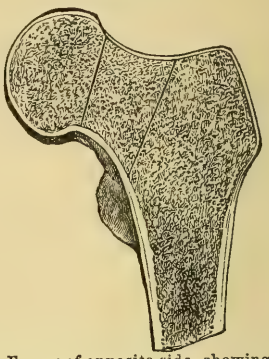


Fig. 205. Femur of opposite side, showing amount of bone absorbed. (Bryant.)

well seen in the accompanying engraving. [See Illustrations to Bigelow's article referred to above. The accompanying cuts (Figs. 204, 205), from Bryant's Surgery,

Fig. 206.

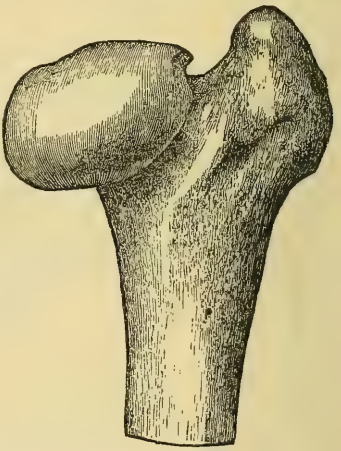


Fig. 206. Interstitial absorption of the cervix femoris. (From the Museum of Westminster Hospital.)

admirably illustrate this point.] In the above case the history showed that the disease had existed prior to the accident, and the diagnosis was therefore simplified; but it not unfrequently happens that the morbid changes—the interstitial absorption of the neck of the thigh-bone, the alteration of the angle which it forms with the shaft, the flattening and expansion of its head—

[1] Smith, On Fractures and Dislocations, p. 113.

and the consequent shortening of the limb, and lameness, are first set up by a blow or a fall on the great trochanter; and it may become a question at a future time whether the bone was not really broken, the nature of the injury having been overlooked or mistaken. A careful examination shortly after the accident will seldom fail to discover its true nature; but old cases of interstitial absorption of the neck of the femur, following a blow on the trochanter, cannot always be distinguished from old fractures of the same part. Ordinary hemiplegia, or paralysis of the lower extremity, can scarcely be mistaken for a fracture; yet certain cases of infantile paralysis bear some resemblance to it; thus, a child while running about will suddenly fall down and complain of being hurt, and, being put on his feet, it is found he has lost the use of one leg. After a time the limb becomes shortened and everted, and the prominence of the trochanter on that side is diminished. Apart from the rareness of a fracture of the cervix femoris in a young child, it must be remarked that most of the above symptoms only manifest themselves some months after the attack of paralysis, and are the result of atrophy of the limb, which ceases to grow at the same rate as the sound one. Examined immediately after the fall, it will be found to be simply paralytic, and there will be an absence of all the usual symptoms of fracture. But if certain accidents and diseases bear some resemblance to a fracture of the neck of the femur, so may this injury be sometimes unaccompanied by many of the symptoms which ordinarily characterize it. An example of this was given at page 933, and it may be remembered that the true nature of the lesion was only discovered after death. There are no signs by which such an injury could be recognized during life: the mode in which it happened, the age of the patient, and the pain within the joint, might lead to a suspicion of its nature, but nothing more. Such cases, however, are so rare, that nothing more need be said respecting them; but they suggest great caution in regard to the treatment of doubtful cases.

TABLE TO ASSIST IN THE DIAGNOSIS OF INTRA- AND EXTRACAPSULAR FRACTURES OF THE FEMUR.

Intracapsular Fracture.	Extracapsular Fracture.	Extracapsular Impacted Fracture.
1. Cause.—Often slight or indirect.	Falls on the trochanter with great force.	Falls on the trochanter with moderate force.
2. Age.—Rare before fifty.	Not peculiar to, though more common in the aged.	Ditto.
3. Sex.—More frequent in females.	Relative frequency in males and females not determined.	Ditto.
4. Shortening.—Not exceeding an inch. Can be removed by moderate extension, but recurs when this is remitted.	An inch and a half to two and a half. Ditto.	Not exceeding an inch. Cannot be overcome without using great force.
5. Position of the limb.—It rests on its outer side.	Ditto.	Inclination outwards less.
6. Position of trochanter.—Nearer the iliac crest than normal, moves in a smaller arc, head of the bone does not move with it.	Nearer the iliac crest, often detached, does not move with the shaft.	Nearer the iliac crest, moves with the shaft, and the head of the bone moves with it.
7. Crepitus.—Difficult to detect.	Crepitus readily detected.	None.
8. Helplessness.—Great.	Ditto.	Limb less helpless.
9. Pain.—Generally moderate.	Often severe.	Generally slight.
10. Bruising.—Generally none.	Frequently evident.	Not generally evident.

Prognosis.—Whether a fracture of the neck of the femur be situated within or without the capsular ligament, the prognosis must always be guarded; lameness, in a greater or less degree, is inevitable in both varieties; but the danger to life is not small, especially in the extracapsular fractures of the aged, the chief causes of death being shock, irritative fever, or gradual exhaustion of the vital powers.

With reference to the proportion of deaths to recoveries, the tables of the Hôtel Dieu show a mortality of nearly one-third; but this is evidently much too high, and is attributable, according to Malgaigne, to the treatment pursued in that institution. The period at which

death ensues will be seen in the following analysis of sixty specimens of fractured cervix, contained in the Museums of the Richmond Hospital and the Richmond School of Medicine, in Dublin, and described by Dr. R. W. Smith. Of these sixty specimens, thirty-two were situated within the capsular ligament, and twenty-eight without, and of the individuals from whom the former were taken,

13 died within 2 months.
10 " " 1 month.
6 " " 2 weeks.

Of the subjects of extracapsular fracture,

19 died within 2 months.
17 " " 1 month.
11 " " 2 weeks.

The above tables, which are gathered from hospital and workhouse practice, probably give a too unfavorable view of the results of this accident, and if the statistics of private practice could be obtained, it would, I believe, show a more favorable aspect. [Agnew says of 176 fractures of the neck treated in the Pennsylvania Hospital only 9 died, and of this number 49 are recorded as intracapsular, only 2 of which died. (Surgery, vol. i., p. 943.) Hyde reports 61 fractures of the neck treated at Bellevue Hospital, 1865–73, with 8 deaths. (N. Y. Med. Rec., July 24, 1875, p. 514.)] The union of a fracture of the neck, external to the capsular ligament, takes place quite as readily as that of the shaft of the bone, and provided the age of the patient is not extreme, or the health impaired, or the accident caused by great violence, a more favorable prognosis may be given than the above [British] figures would indicate.

Fractures of the femur through the trochanter major.—"Oblique fractures," observes Sir A. Cooper, "sometimes happen through the trochanter major, without implicating the neck of the bone." "The first case of this kind I ever saw," he continues, "was in St. Thomas's Hospital, about the year 1786. It was supposed to be a fracture of the neck of the thigh-bone within the capsule, and the limb was extended over a pillow rolled under the knee, with splints on each side of the limb, by Mr. Cline's direction. An ossific union succeeded with scarcely any deformity, except that the foot was somewhat everted; and the man walked extremely well. When he was to be discharged from the hospital, a fever attacked him, of which he died; and upon dissection the fracture was found through the trochanter major, and the bone was united with very little deformity; so that his limb would have been equally useful as before." This fracture appears, from the engraving, to be situated just below the anterior inter-trochanteric line, and to intersect the trochanter near its centre, leaving part of this process connected with the neck of the bone, and the other part with the shaft.

Its distinguishing marks are, "a fixed state of the upper part of the trochanter, whilst its lower part obeys the motion of the thigh-bone; eversion of the foot, and the very perceptibly altered position of the trochanter major; crepitus felt, if a rather free movement be made of the upper part of the limb, and very little diminution of its length. But when the fracture happens below the insertion of the principal rotatory muscles, the lower portion of bone is much raised by the action of the gluteus maximus, and the limb becomes very much shortened and deformed at the place of union by exuberant callus." The treatment need not differ from that which is proper for fractures of the neck of the femur.

Separation of the epiphysis of the caput femoris.—"Fractures of the neck of the femur," observes Holmes,[1] "are hardly known in childhood, and the upper epiphysis is so small, and lies so completely within the hip-joint, that its disjunction is unknown, except perhaps, in the fœtus."

Several supposed examples of this accident have, however, been recorded; one by South,[2] which happened to a boy ten years of age, who had fallen out of a first-floor window upon his left hip. The limb was slightly turned out, but scarcely at all shortened. The thigh could be readily moved in any direction without much pain, but on bending the limb and rotating it outwards, a very distinct dummy sensation was frequently felt, apparently within the joint, as if one articular surface had slipped off another. This was regarded both by Mr. South and Mr. Green, as an example of epiphyseal separation, and he was placed upon a double inclined plane, but he felt so little inconvenience from it, that he several times left his bed and walked about. The result of the treatment is not mentioned. Dr. Post[3] also relates the case of a girl sixteen years of age, whom he supposed was the subject of this accident. She had a child in her arms, and making a false step, felt something give way, which obliged her to lean against a wall. Dr. Post found the limb an inch shorter than the opposite one; the toes turned outwards, no swelling, but some pain at the upper part of the thigh; the trochanter major moved with the shaft, and there was crepitus. It was put up as a fracture, but a permanent shortening of a quarter to half an inch was the result.

Fracture of the epiphysis of the trochanter major.—In the foregoing section it has been shown that a simple fracture may extend through the trochanter major, either from the shaft or the neck of the femur; it has also been shown that this process is generally broken, and sometimes comminuted,

[1] Holmes, Diseases of Childhood, 2d edit., p. 258.
[2] South, note to Chelius's Surgery, vol. i., p. 565.
[3] Post, New York Journ. Med., vol. iii., p. 190.

in extracapsular fractures of the neck of the bone; the above title, however, would imply that it may be fractured independently of the shaft or neck of the femur, and of this there is certainly not sufficient evidence. The trochanter may, however, be separated from the femur, by violence, at an early period of life, before it has become united with the rest of that bone by osseous matter, as in the following case, communicated to Sir A. Cooper by Mr. Aston Key.

A young girl, about sixteen years of age, in crossing the street tripped, and in falling struck her trochanter violently against the curbstone. She immediately rose, and, without much pain or difficulty, walked home; but experiencing an increase of pain, she was admitted, five days afterwards, into Guy's Hospital, and was examined by Mr. Key. The right leg, which was the one injured, was considerably everted, and appeared to be about half an inch longer than the sound limb. It admitted of passive motion in all directions; but abduction gave her considerable pain. She had perfect command over all the muscles, except the internal rotators. No crepitus, or displacement of bone, could be detected on the closest examination. Nine days after the accident she died. The post-mortem examination revealed a fracture which had detached the trochanter from the body and neck of the bone, but without tearing through the tendons attached to the outer side of the process; this so effectually prevented all motion of the fractured portion that the injury could not have been detected during the life of the patient. [Agnew has in his collection a well-marked example of this injury, accompanied by a fracture of the condyles. (Surgery, vol. i., Fig. 764, p. 945.)]

Treatment of fracture of tne neck and upper part of the femur.—The fact of the possibility of bony union in intracapsular fractures being established, there are few cases in which it ought not to be attempted, and the treatment applicable to fractures without the capsule is equally proper for those within. The indications are—if the fracture is not impacted—to bring the fragments into as accurate a relation to each other as possible, and to keep them so during the treatment, which should extend over a period of three or four months. There are two ways of doing this, one by the straight splint, by which extension as well as fixation may be caused, and the other by the double inclined plane or fracture bedstead. Mr. Solly, in a clinical lecture published in the Lancet of August, 1867, advocates the last-named plan; while Professor Hamilton of New York, prefers the straight position, on the ground that patients can endure this position for a longer time with less suffering than the flexed. [The more common method in this country, and we think the better, is extension by the weight and pulley. In this connection we cannot refrain from again quoting from Professor Bigelow's article. "If to extend a limb means to draw it down, impacted fracture, and whatever resembles it, should never be extended, but only steadied by weight or splint. On the other hand, a loose fracture with decided shortening should be first drawn down *to something like its normal length.*" (The italics are ours.) "Or more briefly, treatment consists in immobility, with the previous extension of a loose fracture." "The prognosis, if the patient lives, is favorable for bony union, except in the case of a loose fracture of the small part of the cervix, which if not readily distinguished, had better be disturbed as little as possible."] Whichever of these methods may be adopted, it must not be forgotten that many old people bear confinement badly: retention of urine is not uncommon, and bed-sores are by no means infrequent. Under these circumstances it may be necessary to abandon all attempts to procure union, and allow the patient to rise daily and get about on crutches, as recommended by Sir A. Cooper. In impacted fractures of the cervix, forcible extension of the limb with the view of restoring it to the same length as the other, must not be attempted, or the fragments may be unlocked, and thus placed in a less favorable condition for union. The long straight splint, used simply as a retentive and not an extending apparatus, is therefore all that is needed in this variety of fracture.

Fractures of the shaft of the femur.—These occur most frequently in its middle third. Of 70 cases observed by the writer, 46 were broken in this situation, 16 in the lower third, and 8 in the upper. [" Of 539 fractures of the thigh received into the wards of the Pennsylvania Hospital, 269 were in the middle, 151 in the lower, and 119 in the upper third."—Agnew's Surgery, vol. i., p. 946. This gives just 50 per cent. as occurring in the middle third, while the text gives 65.7 per cent.] Indirect violence occasioned the majority of these fractures; but of those due to direct causes the greatest number, both absolutely and relatively, occurred in the middle third of the bone.

It has been questioned whether a fracture of the shaft of the femur can be produced by muscular action; but of this many instances are on record, in which the production of the fracture cannot be explained in any other manner. Thus Beauchère has given an account of a man, thirty-four years of age, who, while sliding, felt himself in danger of falling backwards, and made a violent effort to keep up; he did not fall, but he heard at the instant a crack high up in the right thigh, which was

found to be broken below the trochanters.[1] [In the Transactions of the Clinical Society of London, vol. iv., Mr. Durham reports a case of spontaneous fracture of the femur in a man forty-four years of age. He was inclined to regard it as a case of "degeneration instead of repair, and absorption of the bony tissues without suppuration," following a severe bruise of the bone.—Am. Journ. Med. Sciences, April, 1872, p. 463. Agnew (op. cit., p. 946) reports two cases, and says, "In all these cases, however, there is a reasonable ground for believing that the bones were unsound."]

Fig. 207.

Fig. 207. Oblique fracture of the lower third of the femur, downwards and forwards. (From St. George's Hospital Museum.)

The mode of production of this fracture will influence to a certain extent its character and direction: thus it may be multiple, or comminuted, or compound, if caused by machinery or the passage of a heavy weight over the thigh; transverse in direction, if caused by a sharp blow, and more or less oblique if by a fall on the feet, or under a heavy load. The direction and degree of obliquity vary greatly; in the upper third of the bone the prevailing direction, according to Malgaigne, is downwards and inwards; in the middle third of the bone, according to the same author, it is downwards and forwards; while in the lower third, we are assured, it is more prone to assume a transverse direction. Oblique fractures are more rare, and not very constant in direction; thus, they may run downwards, outwards, and forwards, or downwards and inwards, or downwards and forwards; or there may be impaction of the upper fragment in the lower. Perhaps the most common direction is downwards and forwards, and the most rare downwards and backwards. In whatever part of the shaft the fracture may be situated, and whatever may be its direction, it is rare that displacement of the fragments does not occur, the lower fragment being drawn upwards, behind, and generally a little to the inner side of the upper; and sometimes acting upon the latter, so as to cause it to project forwards or outwards, or inwards, and thus produce more or less angular distortion. This is best seen and most frequently observed when the fracture is situated in the upper third of the bone, and the distortion so occasioned has been attributed to the action of the psoas and iliacus muscles drawing the upper fragment forwards; but that this is not the sole cause may be easily proved by an examination of the numerous specimens of this fracture in our London museums. From these it will be seen that the displacement of the upper fragment may be in any direction; outwards, inwards, forwards, or backwards, which could not be the case were its position solely dependent on the action of its own muscles. This is important as respects the treatment of fracture of the femur in its upper third, and the more so because our great authority, Sir Astley Cooper, has omitted all mention of any other distortion than of the upper fragment forwards and upwards, which he attributes to the action of the psoas and iliacus muscles, assisted by the pectineus; and "to prevent this horrid distortion, two circumstances," he says, "ought to be strictly observed: the one is to elevate the knee very much over the double inclined plane; and the other to place the patient in a sitting position, supporting him by pillows during the process of union."[1] Now the predominant direction of the displacement of the upper fragment is not directly forwards, but outwards and forwards; and the specimen of this fracture which Sir Astley has had figured in his work is an example of the displacement of this fragment directly outwards, a position which has evidently been brought about by the action of the lower fragment upon it; the latter is at the

[1] Beauchère, Journ. de Méd. de Leroux, tome xxx., p. 336.

[1] Op. cit., p. 191.

same time rotated one-fourth of a circle outwards, so as to bring its anterior surface to correspond with the external surface of the upper fragment; and hence the apparent projection of the latter forwards and upwards.

Fig. 208.

FIG. 208. Sir A. Cooper's specimen of fracture of the upper third of the femur. (In St. Thomas's Hospital Museum.)

Fig. 209.

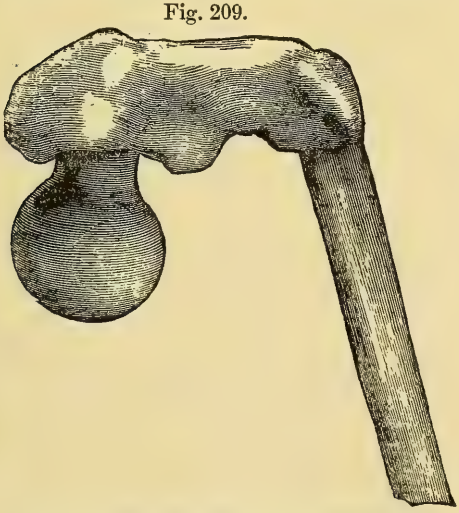


FIG. 209. Rectangular union of fracture of the upper third of the femur. (From the Museum of Westminster Hospital.)

A very fine example of the tilting of the proximal fragment directly upwards is figured above. The specimen was removed from a female brought to the Westminster Hospital for dissection, and is described by Mr. Heath in vol. xi. of the Pathological Society's Transactions.

Combined with the displacements in the axis of the limb, or at right angles with it, are those by rotation: in a large number of our museum specimens, one or both fragments are seen to have undergone some rotation on their axis; but, in the absence of any history with the greater number of them, it is impossible to say whether such rotation was of the upper fragment, or of the lower, or of both; or how much of it might be due to direct muscular action, and how much to mere physical causes.

Symptoms and diagnosis.—The usual symptoms of a fracture of the shaft of the femur are, shortening and deformity of the thigh, which is generally unnaturally curved, with the convexity forwards and outwards; eversion, and loss of power of the limb; pain, and abnormal mobility at the seat of fracture; and crepitus on rotation. The nature of the injury is so very apparent, that it cannot easily be mistaken for any other; but the determination of the direction of the fracture, whether transverse or oblique, is by no means easy, and not always possible. If the fracture be in a young child, if it have happened from direct violence, if it be situated near the centre of the shaft, and if the shortening of the limb be inconsiderable, the fracture is assumed to be transverse in direction; but a nearer approach to accuracy may be arrived at by attending to the circumstances under which crepitus may be elicited; if this phenomenon can be evoked in a shortened limb, without previous extension, it is presumptive evidence that the fracture is oblique; if, on the contrary, the limb be shortened, and rotation produce no crepitus till it has been restored by extension to its normal length, we may reasonably presume that the fracture is a transverse one.

Prognosis.—The prognosis of a fracture of the shaft of the femur must depend on its nature, the mode of its production, and the age of the patient. If the fracture be compound, or complicated with the wound of a large vessel, or extend into the knee-joint, the prognosis must be guarded, though not absolutely unfavorable. If it occur in an old person, and from great violence, as from a railway-carriage passing over the limb, or if it be compound and communicate with the knee-joint, the case is one of the greatest danger, and the prognosis will be most unfavorable. On the contrary, a simple fracture of the shaft, if properly managed, and uncomplicated with other injury or disease, will nearly always do well; and though some shortening of the limb usually results, it is insufficient to

impair its usefulness, or to cause more than a slight lameness; a favorable prognosis may therefore be given.

Treatment.—Much contrariety of opinion prevails respecting the possibility of curing a fracture of the femur, in the adult, without shortening; and from the time of Hippocrates to the present day, the profession has been ranged in two opposite camps—one side declaring that shortening of the limb may be prevented, and the other as positively denying it.

To determine this question, and without bias either on one side or the other, the writer employed some of his leisure hours in the summer of 1857 in examining all the fractured thighs then under treatment in the different hospitals of this metropolis, till he had procured nearly the same number of cases of this accident from each. To insure accuracy, each limb was measured by a graduated tape from the anterior superior spinous process of the ilium—1st, to the lower border of the patella; 2dly, to the extremity of the outer malleolus; and 3dly, to that of the inner; and the result was written down on the spot. The total number of patients thus examined was 50, of whom 41 were males, and 9 were females. Their ages varied from 84 to 2 years; 30 being adults, and 20 children under 15 years of age. Now of the total number, only 15 escaped deformity, and of these 12 were children, leaving, therefore, but 3 adults out of 30 in whom no shortening had taken place, and showing that under the present mode of treating these fractures in the London hospitals, shortening of the limb follows in 90 per cent. of the adults admitted, and in 40 per cent. of the children. Even this high percentage is probably underrated as regards adults; for, in truth, two of the latter in whom no shortening was found were recent admissions, the accident having happened but two days previously in the one case, and four days in the other, rendering it therefore doubtful what the ultimate issue might be: even the single case in which there was no shortening is not free from suspicion, for although the accident had occurred five weeks before, the long splint was still on, and in the absence of examination without it, one could not be sure that the limb had been fractured. The writer's individual experience at the Westminster Hospital is entirely confirmatory of the above results obtained at all the other hospitals; and with the full knowledge of this tendency to shortening in fractures of the femur, and with every attempt to prevent it, he has not yet succeeded in a single case in the adult, nor has he found, in upwards of 100 specimens of this fracture which he has examined in the various museums of the metropolis, more than one in which there was not some shortening. With reference to the amount of shortening in the 35 cases out of the 50 already mentioned, it was—

½ an inch in	4	1½ to 1¾ inches in	4
⅝ " "	2	2 " "	3
¾ " "	10	2½ " "	1
1 inch "	9	3⅓ " "	1

and in one it was not ascertained, both thighs being broken.

These results of the writer's own observations are fully confirmed by Malgaigne and Hamilton; the former of whom bears this strong testimony on the subject: "There has been too much discrepancy of opinion among surgeons in regard to this (shortening). Hippocrates gives the idea that the shortening can always be obviated; Celsus goes to the opposite extreme, declaring that a thigh once broken must ever remain shorter than its fellow. At a period by no means remote from our own, Desault claimed to cure all fractures without shortening, and his journal contains several such cases. In imitation of him, many surgeons have varied, corrected, and improved apparatuses for permanent extension, and have announced complete successes from them. I must, however, state positively that I have never obtained anything of the kind, either with contrivances of my own, or with those of others, or even when I have invited the inventors of such apparatuses to apply them in my wards. I have more than once examined persons said to be cured without any shortening, but always discovered such shortening by careful measurement. The mistake of all those who have thought they had obtained these miraculous cures was, that they never dreamed of comparing the two limbs in regard to their length; I will say, moreover, that they were most commonly ignorant of the proper way to obtain a good and correct measurement. Some have been deceived in another way; they have lighted upon fractures with interlocking, especially in young subjects, and have imagined that they had corrected by treatment a shortening which never existed. In short, when the fragments remain in contact, or when we can replace them and keep them so by means of their serrations, it is easy to cure a fracture of the femur without shortening; in the absence of these two conditions the thing is simply impossible."[1]

Hamilton also states, that "in case of an oblique fracture of the shaft of the femur occurring to an adult, whose muscles are not paralyzed, but which offer the ordinary resistance to extension and counter-extension, and where the ends of the bone have once been completely displaced, no means have yet been devised by which an overlapping and consequent shortening of the end of the broken bone can be prevented." He also affirms that "the average shortening in simple fractures, where the best appliances and the utmost skill have been employed, is about [in his 6th edition Hamilton says "from half to three-quarters of an inch."] three-fourths of an inch."[2]

[It is perhaps hardly necessary to remind the American readers of the repetition of this old contest between shortening and no shortening, that was carried on with renewed vigor a few years since in periodicals,

[1] Malgaigne, op. cit., p. 723.

[2] Hamilton, op. cit., 3rd edit., p. 405. Notwithstanding this strong testimony, surgeons are still to be found hardy enough, or ignorant enough, to repeat the fallacies which have been so often refuted, and to vaunt their success in the cure of oblique fractures in the adult, without shortening. Why do not these surgeons, instead of publishing their cases in the journals, produce their patients at some of the medical societies?

and in the meetings of the American Medical Association. The sentiment of the latter body found expression in the resolution that "shortening, in cases of fractures of the long bones, is the rule in practice, regardless of any of the means of treatment now in use." This resolution was adopted almost unanimously at the meeting in 1878, one distinguished surgeon entering his protest in the negative. In this connection it may not be superfluous to draw attention to the possible inaccuracies of measurement in the most skilful hands; but since the last edition of this work was published, one fact has been presented, which materially affects all measurements. We refer to inequality in the two limbs in uninjured persons. Cox (Am. Journ. Med. Sciences, April, 1875, p. 438), reports measurements on 54 individuals, in only six of whom he found the two limbs symmetrical; the difference between the two in 48 cases varied from $\frac{1}{8}$ to $\frac{3}{4}$ of an inch. To show that this difference was not entirely due to any peculiarity of the living tissues, Roberts (Phil. Med. Times, Aug. 3, 1878, p. 518), measured seven skeletons that showed no sign of injury, and found a difference in each case, varying from $\frac{1}{8}$ to $\frac{3}{4}$ of an inch. Granting the truth of these observations we see at once that the whole question of shortening is placed in a new light.

We think, however, that the statistics of our American surgeons, so far as they are accessible to us, give rather more favorable results than those given in the text. Thus Buck, in 1867 (Med. Record, April 1st), reported "89 cases in adults, in 12 of which there was no shortening; maximum $1\frac{1}{2}$ inches in 2; average scarcely $\frac{1}{2}$ an inch." Hyde (Med. Record, July 31, 1875, p. 513), reports 254 cases, age not given, both simple and compound, in which the average shortening, including 18 not shortened, was a trifle over $\frac{1}{2}$ inch. St. John (Am. Journ. Med. Sciences, July, 1872, p. 75), gives 50 cases of all ages, in which the average shortening was $\frac{1}{3}$ of an inch. In 18 cases it is claimed there was no shortening: 21 cases over 18 years average less than $\frac{1}{4}$ inch. Sands (N. Y. Med. Journal, June, 1871), gives 14 cases over 15 years, and of these in 6 cases there was no shortening; maximum 1 inch; average $\frac{1}{3}$ of an inch. Sayre (Transactions Am. Med. Association, 1874), reports 26 cases of all ages (19 over 20 years), in which the average shortening was less than $\frac{1}{2}$ an inch. Agnew says conclusively "that a fracture in the shaft of the thigh bone, which is cured with one-half or three-quarters of an inch shortening is a good cure, and gives no room for complaint on the part of the patient; and that the surgeon who obtains this result may walk among his professional brethren without being conscious of the least inferiority or want of skill in the management of this class of surgical injury." Op. citat., p. 949.]

The causes of these different results in the adult and in the child probably depend on the different chemical composition of the bones at these two periods of life, and the modifying influence which this exerts on the form and completeness of the fracture. In the child, too, the periosteum is thicker, and in many cases only partially torn through—or not torn through at all—so that complete displacement of the fragments does not take place.

In the treatment of fractures of the shaft in the adult, three indications should be fulfilled,—1, coaptation and fixation of the fragments; 2, moderate extension; and 3, gentle compression and support of the limb. Provided these requirements are carried out, it matters little what apparatus may be employed; but that which can be applied with the least disturbance of the fractured bone, and is most comfortable to the feelings of the patient, should be preferred. The time has gone by when the relative advantages of the straight and of the flexed position are worth discussing, the great majority of surgeons in all parts of the world being agreed on the superiority of the former. Fractures even which were thought pre-eminently to require a flexed position of the limb, as those in the upper third of the thigh, are now usually treated in the straight position. There are three principal ways of doing this: in one it is effected by means of a long splint on the outside of the limb, extending from the axilla to a few inches beyond the foot, as in the splint which goes by the name of Liston's. This provides not only for the immobility of the whole limb and trunk, but acts also as an extending apparatus. The following is the ordinary mode of applying it:

The patient lying on his back on a firm flat mattress, a few turns of a roller should be first carried round the foot and ankle; then the splint, well padded on its inner side and reaching from a point opposite the nipple to four or five inches beyond the foot, must be laid on the outside of the fractured limb, and firmly secured to the latter by several more turns of the same roller around the foot and ankle and splint, and through the notches at its lower extremity; it may then be carried upwards as high as the knee. At this stage of the proceeding traction should be steadily made on the limb by assistants, till its length equals, or even slightly exceeds, its fellow, as ascertained by measuring with a tape from the anterior superior spinous process of the ilium to the lower border of the patella. When this has been effected, the perineal bandage must be applied, its padded centre resting on the perineum, and its two ends passed through the holes in the upper part of the splint and tied on its outside. By this means the splint is prevented from ascending, and by tightening the perineal bandage, it can even be forced downwards, and powerful traction thus exerted on the limb. Lastly, the remainder of the limb should be encircled by the roller, and the upper part of the splint bound to the trunk by a few turns of a broad rib-bandage. This method of treat-

ing fractures of the thigh, though so generally adopted, is not free from several grave defects. In the first place, the application of the circular bandage to the limb necessarily involves much handling of the fracture, and consequently, more or less disturbance of the fragments, while at the same time it is next to impossible to keep up sufficient extension during the somewhat tedious process of bandaging from the toes to the trunk. Moreover, however skilfully it may be put on in the first instance, in a few days it becomes loose, and a repetition of the process is necessary. For these reasons I hold it to be preferable to substitute for the roller a sheet or tablecloth, as recommended by Mr. Syme, or towels, or broad bands with buckles, or, indeed, anything which will effectually maintain the splint in position, without making unequal pressure on any part of the limb, and which does not require, during its application or readjustment, the holding up of the limb which is necessitated by the ordinary bandage. The next objection to this method is the perineal bandage, which, if tight enough to keep up effectual traction on the limb, is apt to cause ulceration of the skin in the neighborhood of the ankle and perineum, or œdema of the limb by its pressure on the veins of the upper part of the thigh. To obviate this, Hagedorn's splints, as modified by Gibson, may be used, the principle of which consists in having a crutch affixed to the upper end of the splint, whereby the counter-extension is made from the axilla instead of the perineum. In this apparatus a similar splint is applied to the sound limb, and the lower ends of each pass through a footboard to which the feet are attached. Or De Morgan's long splint and pulleys may be applied to the opposite limb. This consists of a long, straight, stout splint, with a piece of wood about a foot in length let in at right angles to it about six inches from its lower end. The long arm of the splint is well padded on its inner side. An inch or two from the upper end of the splint is a small pulley, fixed in an aperture made for the purpose; a similar one is placed at the lower end. That part of the splint which is let in at right angles is provided with a slit extending nearly its whole length, admitting another pulley of similar size, which can be shifted to various parts by means of an iron pin passing through holes bored in the sides of the cross-piece. A strong piece of strapping is now applied to the sides of the leg, leaving a loop at the sole of the foot, as in the ordinary way, care being taken that the loop shall be large enough to admit a tightly-rolled leg-bandage; this being placed transversely at about the middle of the sole of the foot, so that it is enabled to receive all lateral pressure when extension is applied. Without this, the strapping would cut the hollow and outer side of the foot, and give rise to considerable pain and inconvenience. In cases of fracture of the leg, the strapping should not come above the seat of injury. The foot should now be bandaged, so as to retain the strapping firmly. A piece of strong cord is then fastened to the loop of plaster, so as to include it and the roller, and this gives us a fixed point to pull upon from below. The cord, thus fastened, is next passed over the pulley which lies in the slit in the cross-piece, then over the pulley at the lower end of the splint, and is carried to about the middle of the outside of the long side-piece. Here it is attached to one end of a patent elastic door-spring, or accumulator. To the upper end of the elastic is attached a piece of

Fig. 210.

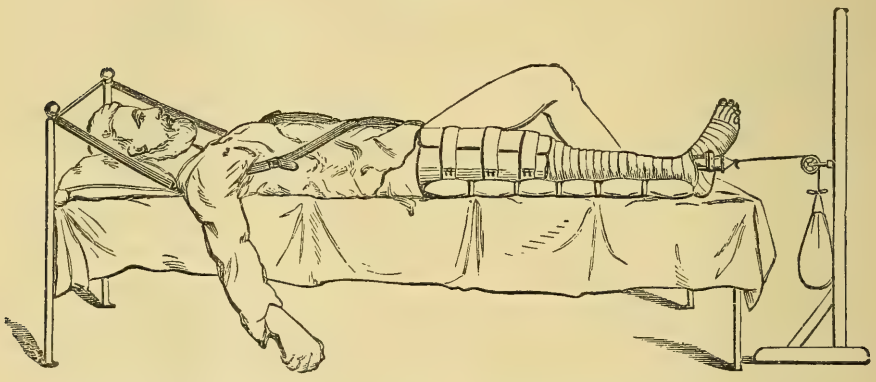


Fig. 210. Extension apparatus for fracture of the thigh. (Modified from Gurdon Buck.)

wood,[1] about four inches long, one inch broad, and half an inch thick, perforated by three holes equidistant, and just large enough to admit the cord used. By one of these holes, it is secured to the elastic. A well-padded perineal band is now applied, to the upper part of which a separate piece of cord is fastened. This is brought over the pulley at the upper end of the splint, and then made to perforate successively the two remaining holes in the piece of wood attached to the elastic. It will now be evident that, by slipping this piece of wood up the cord fastened to the perineal band, the elastic will be put on the stretch, and, in this way, extension may be regulated to a nicety.

The limb may now be brought into position, and extension applied as far as is deemed proper. In all cases I hold it to be advisable to apply short splints to the thigh; and indispensable to do so when the fracture is in the upper third of the bone.

Dr. Gurdon Buck believes that better results may be obtained when the extension is made by means of a weight and pulley, as seen in the engraving. [Dr. Levis has devised a very simple attachment for the weight and pulley which admits of universal application (Fig. 211) (see Phil. Med. Times, May 25, 1878).] In this apparatus the long splint is dispensed with, and the thigh only is surrounded with four short splints, while counter-extension is provided for by means of a perineal band, having its two ends made fast to the head of the bedstead. "The advantages claimed for this method over others heretofore in use, are its great simplicity of arrangement, facility of management, and especially the comfort it affords the patient during a long confinement in bed.[2] [One or two improvements have been made since the publication of the last edition of this work. The most important is dispensing with the perineal band, and in place of it, raising the foot of the bed by blocks from four to six inches high, thus producing counter-extension by the weight of the patient's body. Another is the introduction of a stout rubber ring between the block in the stirrup and the cord, thus giving a certain degree of elasticity: it also serves to diminish the amount of weight necessary. But more important than the last is the application of a long splint extending from the chest below the foot with a cross-piece at its lower extremity resting upon the bed, to prevent rotation. This is more effectual than the use of sandbags, and we think it removes entirely the only valid objection to this apparatus, viz. that it did not prevent rotation.] It is only fair to the late Mr. James of Exeter, to state that he made use of the weight and pulley many years before it was employed in America.

Fig. 211.

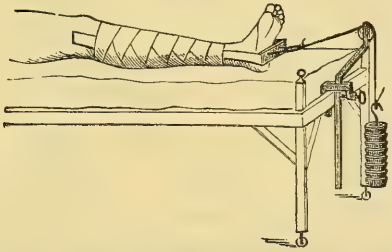


Fig. 211. Levis's attachment for weight and pulley.

The third mode of treating fractures of the thigh in the extended position is by one of the various forms of the so-called immovable apparatus. In spite of their unquestionable value in a large number of fractures, I must dissent from the propriety of their application to recent fractures of the thigh in the adult, on the grounds already stated against the ordinary circular bandage.

As Mr. Erichsen is, I believe, the only London surgeon of note who advocates the employment of the immovable apparatus, in recent fractures of the thigh, I here subjoin his directions for applying it. "The whole limb is enveloped in a layer of cotton-wadding, which is thickly laid along and over the osseous prominences; over this should be laid splints of thick and coarse pasteboard soaked in thin starch, properly shaped to fit the limb, extending beyond, and fixing securely the two joints above and below the fracture: the hip and knee when the thigh is broken; the knee and ankle when the leg is fractured. The pasteboard should be soft, not milled, and be doubled and torn down, *not* cut, as in this way the edges are not left sharp. If much strength be not required, as in children, or in some fractures of the upper extremity, a few slips of brown

[1] Similar to what is used for tightening the ropes of tents. It is used here on the same principle, and was suggested by Mr. De Morgan.

[2] Description of an Improved Extension-Apparatus for the Treatment of Fracture of the Thigh, etc., introduced by Gurdon Buck, M.D., Surgeon to the New York Hospital, St. Luke's Hospital, etc., etc.

paper, well starched, may be substituted for the pasteboard. A bandage saturated with thick starch must now be firmly applied; and lastly, this is to be covered by another dry roller, the inner sides of the turns of which may be starched as it is laid on. I always take especial care not to apply any roller or bandage directly to the fractured part under the splints, and always to include in the starched apparatus the two joints that are connected with the broken bone, so that complete immobility of the fragments may be secured. During the application of this apparatus, extension must be kept up by an assistant, so as to hold the fracture in position, and, until the starch is thoroughly dried, which usually takes from thirty to fifty hours, a temporary wooden splint may be applied to the limb, so as to keep it to its proper length and shape."[1]

[In this country the treatment of fractures of the thigh may very generally be included under one of three methods, viz., the use of Buck's apparatus, of Hodgen's modification, of Smith's anterior splint, and of plaster-of-Paris. Of Buck's apparatus with the long splint, Hamilton in a clinical lecture (Med. Rec., Dec. 1, 1877, p. 753) says, "It is the model dressing for fracture of the thigh occurring in adult life." English surgeons have not been slow to acknowledge the advantages of the first two methods, which, according to Prof. Van Buren (Med. Record, March 30, 1878, p. 241), are alike essentially American. Thus, Mr. James Spence (Med. Times and Gazette, August 21, 1875, p. 204) gives his unqualified approval to the method of extension by weight and pulley, although he fails to identify Dr. Buck with it; and Mr. Cooper Forster (Guy's Hospital Reports, 1876, p. 117) says of the Hodgen splint that it is "theoretically the most perfect splint yet devised;" he reports 12 cases treated by this splint, in which the average shortening was ⅛ of an inch. In spite, however, of these favorable results, we think that the Hodgen splint is far less frequently used by American surgeons than Buck's extension.

The method of treating fractures of the femur by plaster-of-Paris has been extremely popular with some American surgeons, and especially with some of those connected with Bellevue Hospital, New York. Notwithstanding the disapproval of so distinguished an authority as Professor Hamilton, it has been extensively employed, and with apparently excellent results. The statistics given above by Sands, St. John, and Sayre, are the results of treatment by plaster-of-Paris. The different methods of applying it have been given in detail in another portion of this work. We must confess to a strong leaning to its use. Its advantages are by no means inconsiderable. It requires no little care and practice in the application, and it needs to be carefully watched. But with these we do not question that on the whole, at least as good results are obtained as by any other method. We cannot hesitate to prefer the plaster-of-Paris splint to that form of immovable apparatus described in the text.]

Fig. 212.

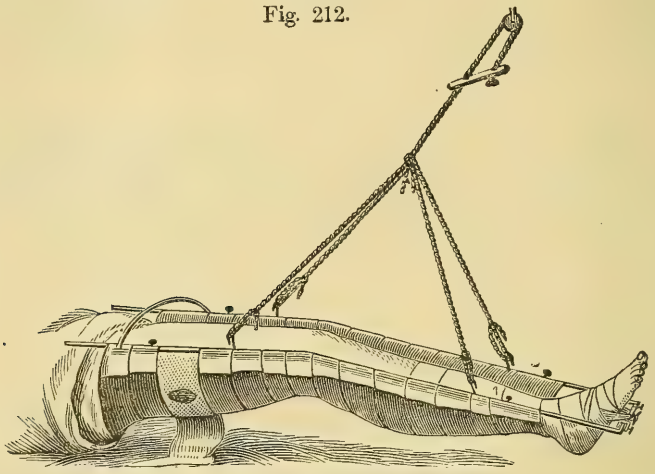


Fig. 212. Hodgen's suspension apparatus.

While advocating the straight position for fractures of the thigh generally, I would by no means be understood to deny the occasional propriety of adopting the flexed, and for this any of the many fracture beds in use are preferable to the simple double inclined plane. The bedstead is not intended to supersede the employment of lateral splints, which should extend from the trochanter to the knee on the outer side, and from the perineum to the same point on the inner, and be firmly secured by straps and buckles.

A few words must be added on the treatment of these fractures in infants and young children. For them it is seldom necessary to do more than encircle the thigh from the knee to the hip with soap-plaster spread upon leather, care being taken that it is not applied too tightly, and that the skin in the perineum and its neighborhood is kept dry and clean by changing the napkins the moment they become soiled, and washing the parts from time to time with

[1] Erichsen, Science and Art of Surgery, 5th edit., vol. i., p. 242.

a solution of alum: a little lapis powder dusted on the parts, or zinc ointment rubbed in, is an excellent preservative against inflammation and excoriation. [Hamilton recommends for these cases parallel outside splints for both limbs, extending from the axillæ below the feet with a cross-bar uniting them at the bottom. Coaptation splints of felt are used over the seat of fracture (Med. Record, January 5, 1878, p. 1).] In older children, splints

Fig. 213.

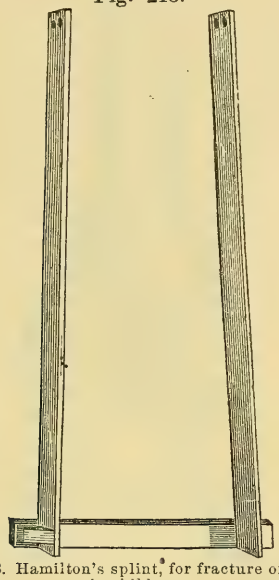


Fig. 213. Hamilton's splint, for fracture of femur in children.

of leather or gutta percha, or the immovable apparatus may be applied. Whatever plan of treatment may be selected for these fractures, it is essential to bear in mind that the amount of shortening is, to a great extent, within the control of the surgeon; and though he may fail to prevent it altogether, he may greatly diminish it by care and frequent supervision. As respects the duration of the treatment for a simple fracture of the thigh, it will average from two to three months in an adult and from six weeks to two months in a child. It is by no means necessary that patients should remain in bed all this time; six weeks will generally be long enough for an adult, and four weeks for a child; after which the immovable apparatus should be applied, and they may be allowed to go about on crutches; but they will seldom be able to dispense with all support to the limb under the period mentioned above.

In compound fractures, unless both the soft parts and bone are crushed, or the principal bloodvessels or nerves of the limb torn through, or the knee-joint opened, amputation should not be performed; but a long interrupted splint applied on the outer side of the limb, and the wound treated on general principles. [For the treatment of compound fractures of the thigh as well as of all other limbs, we think plaster-of-Paris with fenestra presents vast advantages over all other methods. It gives ample opportunity for the application of

Fig. 214.

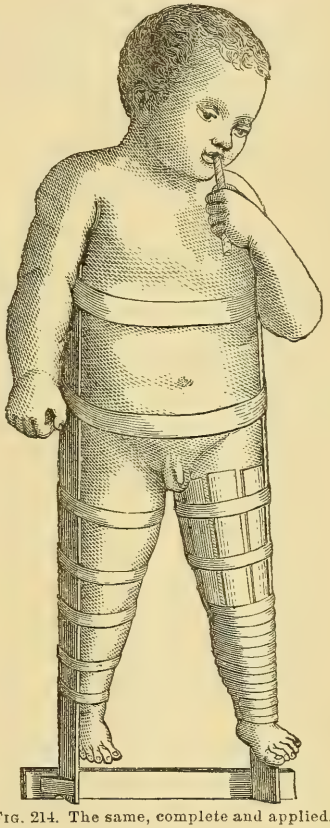


Fig. 214. The same, complete and applied.

antiseptic dressings, and admits of such manifold variety in its application, that we would in these cases give it the highest place.] In some cases, the long splint may be dispensed with, and even the short thigh splints—extension and counter-extension being provided for by the weight and pulley, and a perineal belt, while inversion or eversion of the foot is prevented by sandbags placed on each side of the leg. Out of twenty-one cases of compound and comminuted fractures of the thigh, taken indiscriminately and treated in the above manner by Surgeon Van Steinberg, of the 53d N. Y. S. V., nineteen recovered with tolerably useful limbs.[1]

[1] J Swinburne, American Medical Times, 1863, vol. i., p. 149.

Fractures into the knee-joint.—These may involve each or all of the bones entering into the formation of the joint, and the gravity of the accident will be in direct relation to the number of the bones implicated, their degree of comminution, and whether the fracture be simple or compound. Fractures of the femoral part of the joint may be situated either above the condyles or through them; and may be transverse, oblique, or vertical. Not unfrequently they are multiple, the two condyles being detached from the shaft by a transverse fracture, and from each other by a vertical or oblique fracture. The latter also may traverse either condyle, or the intercondyloid space. In young children the epiphysis is sometimes separated from the shaft, and this may be combined with a fracture through one of the condyles.

Chips of bone or portions of articular cartilage are also occasionally detached from the condyles into the joint, as in a case recently recorded by Professor Volkmann, of Halle, where after a heavy fall on the knee while the limb was in a state of acute flexion, a portion of the cartilage of the inner condyle, measuring nineteen mm. in diameter, was broken off, and gave rise to symptoms of "loose cartilage." Between four and five months after the accident this foreign body was extracted by an incision about two-thirds of an inch long, made directly down to it, the skin having been previously displaced so that the skin wound should not afterwards coincide with that into the joint capsule. The limb was put up into a plaster-of-Paris splint, and the patient recovered without a bad symptom."[1]

Fractures of the head of the tibia are more rare, and, unless compound, they are not usually dangerous; nevertheless, lameness not unfrequently results from the inflammation which these fractures set up in the knee-joint, and the permanent stiffness which follows.

These injuries are sometimes caused by getting the leg between the spokes of a wheel in motion, by falls on the knee, or by kicks. The nature of the accident is recognized by the mobility of the fragments, the crepitus, the swelling of the joint, and the impossibility of bearing any weight on the limb.

No absolute rule can be laid down as to the position in which the limb should be placed in the several varieties of fracture. For the majority, the straight is undoubtedly the best, as the pressure of the articular surfaces on each other insures the juxtaposition of the fragments. In other cases again, it has been found that the fragments could only be kept in place by flexing the leg, and where a vertical or oblique fracture separates the condyles, lateral pressure may also be required. If much inflammation arise, it may be reduced by leeches, fomentations, or evaporating lotions, as most agreeable to the patient's feelings. Passive motion should be commenced in five or six weeks to prevent anchylosis. In compound fractures into the joint, amputation of the limb will generally be necessary.

Fig. 215.

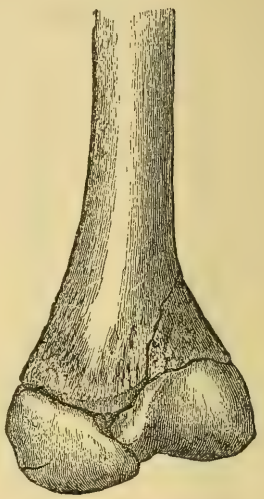


Fig. 215. Separation of the lower epiphysis of the femur, combined with fracture. (From the Museum of St. George's Hospital.)

[Since the general use of the antiseptic method this rule admits of a much greater latitude. Many compound fractures of the knee-joint have been cured by the application of Lister's method and fixed dressings. So long as the integrity of the vessels, nerves and muscles is moderately preserved, an effort to save the limb in the manner specified may be made with a very fair hope of success.]

Fractures of the Patella.

Fractures of the patella present the same varieties as fractures of other bones; they may be simple, comminuted, or compound; vertical, oblique, or transverse; and are caused either by direct violence, as falls or blows upon the knee, or by muscular action. Of all the bones of the skeleton, the patella is most liable to be broken from the latter cause; and the frequency of its occurrence would imply some peculiarity in the structure or position of this bone. [Hamilton, in his Study of Fractures of the Patella (published in New York, 1880), reports 127 cases, of which 119 occurred between the ages of 20 and 70, and of the whole number 99 were males and 28 females;

[1] Deutsche Klinik, 1867, p. 448. See also Teale, Med-Chir. Trans., vol. xxxix; Brodhurst, St. George's Hospital Reports, ii. p. 41.

p. 82.] As regards structure, Malgaigne affirms that these fractures are sometimes favored by an antecedent morbid condition of the bone; but this will not explain their greater relative frequency as regards the other bones of the skeleton, unless it can be shown that the patella is more prone to this morbid change than they are. As respects position, when the knee is slightly bent, the patella is supported upon the condyles of the femur on its transverse axis only, while its upper half is unsupported behind, and its superior edge projects slightly upwards. Under these circumstances, a sudden and violent contraction of the extensor muscles of the leg, which are now nearly at right angles with the vertical axis of the patella, may snap the bone in two, as not unfrequently happens when a violent effort is made to prevent oneself falling backwards, or in voluntarily throwing oneself backwards to avoid falling forwards. Fractures of the patella by muscular action are always transverse,

Fig. 216.

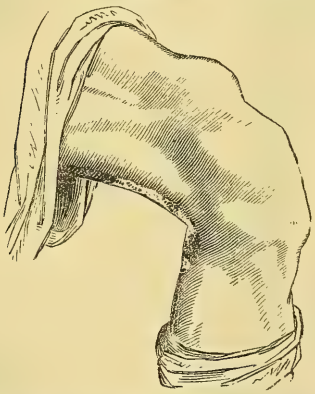


FIG. 216. Separation of the fragments in moderate flexion, when the whole aponeurosis and tendon are torn.

or nearly so, and generally take place through the centre of the bone, though they may be above or below it. The frequency of fractures in this direction seems to have led English surgeons to the belief that the majority of fractures of this bone are of muscular origin. This is contrary to the experience of foreign surgeons, who attribute the greatest number of these fractures to direct violence: thus, of nine cases related by Boyer, five were caused by falls on the knee, which accident likewise produced eleven of the nineteen fractures observed by Malgaigne; while of fourteen which came under the observation of Hamilton, thirteen were the result of direct blows or falls on the knee, and only one was due solely to muscular action. [Hamilton found that the fracture was produced by muscular action alone in 25 of 127 cases. He says: "I believe, however, that muscular action was more or less efficient in causing the fractures in all of the simple transverse fractures, and in at least one of the comminuted fractures; that is to say in 107 of the 127 cases."—Op cit., p. 38.] The extent to which the fragments may become separated in transverse fractures of the patella, is subject to considerable variation, and depends chiefly on the mode in which the accident happened. In a fracture from a blow, the patient may not fall down at all; in one from a fall on the knee he falls forwards or sideways; but in a fracture from muscular action, he falls backwards, with the leg under the thigh. In the two former instances there may be little or no laceration of the fibrous structures attached to the patella, the fragments of which may be only slightly separated; but in the latter, owing to the sudden and violent contraction of the quadriceps, and the forcible flexure of the knee in falling, the soft parts will be more extensively lacerated, and the separation of the fragments correspondingly great. [Marcy (Boston Medical and Surgical Journal, Oct. 8, 1874, p. 364), reports a case of transverse fracture of *both* patellæ in a woman from a misstep; the separation at the time amounted to two inches. Ligamentous union with a separation of from one-quarter to half an inch supervened.] This I believe to be true, as a general rule; but in two patients recently under my care at the same time, the greater separation was in the one in which the fracture had been produced by direct violence.

[Mr. Hutchinson (Med.-Chir. Trans., London, vol. 72) attributes the displacement "not to muscular traction from without, but to fluid pressure from within," and "the real cause of weak union is the bulging of fluid between the fragments." These views, although advanced more than ten years ago, have not we think received general assent.]

Symptoms and diagnosis.—The symptoms of fracture of the patella are generally well marked; when transverse, the separation of the fragments leaves a depression in front of the joint, into which the fingers may be inserted, and the condyles of the femur readily felt. Above and below this depression, the fragments of the patella may be recognized, and on bending the knee, the interval between them will be greatly increased. The power of extending the limb, or of bearing any weight upon it, is lost or impaired. In some cases little more than a transverse fissure can be detected, the bone being evidently fractured, but its fragments retained in apposition by the periosteum. In other cases symptoms are present which resemble frac-

ture, though none exists: thus a fall on the knee may tear across the fibrous capsule, and leave a transverse fissure; or a slight effusion into the bursa patellæ sometimes resembles a fracture, or the bursa may become thickened in parts, and so convey to the fingers the sensation of ridges on the surface of the bone. In vertical and comminuted fractures of this bone, the fragments can be easily brought into juxtaposition, and crepitus elicited. All the varieties of this fracture are followed by more or less inflammation in the knee joint, which not unfrequently becomes greatly distended with fluid, and thus separates still further the broken portions of bone. From this cause I have seen the nature of the injury overlooked, and the case treated as one of synovitis only.

Pathology.—It is rare for a patella which is broken transversely to become united by bone; more frequently the fragments are united by a ligamentous tissue, which varies in length from half an inch to an inch, although it may greatly exceed this, as in a specimen exhibited by the writer at the Pathological Society, figured on the present page, and where the distance between the fragments is two inches and a half. Not unfrequently, however, the fragments remain ununited, being connected with each other merely by a portion of the fibrous capsule of the knee-joint, thickened, and having incorporated with it the bursa naturally existing on the front of the patella. In this case, the aponeurotic structure may pass either from the periosteal surface of one fragment to that of the other, or it may be reflected over both fractured surfaces; or, what appears to be the most common deviation, it may pass from the periosteal surface of the upper fragment, to the articular edge of the lower, as seen in the engraving (Fig. 218). Of thirty-one specimens examined by Mr. William Adams, to whom we are indebted for these observations, fifteen were examples of ununited fracture, twelve of true ligamentous union, and four were doubtfnl from their being dried.[1] In these ununited fractures the fragments may be separated to the extent of five inches, whereas in true ligamentous union, the separation rarely exceeds an inch and a half. [Howe (Boston Med. and Surg. Journal, August 16, 1877, p. 179) reports 59 cases treated at the Mass. Gen. Hospital, where the average amount of separation before treatment was 1.1 inches, and after treatment 0.33 inch. In two cases there was supposed to be bony union. The writer had one case in which, after four years, not more than $\frac{1}{8}$ inch can be detected between the fragments, although at the time of the accident the separation was $1\frac{1}{2}$ inches. Dr. Hamilton (op. cit., p. 84) says that of 127 cases, the union was distinctly stated to be fibrous in 84: in four or five cases the bond of union between the fragments was so short that they could not be moved upon each other, and therefore it "may be constituted of bone;" in three cases no union occurred.] Notwithstanding this holds good as a general rule, most surgeons must have met with cases in which good ligamentous union has taken place, the fragments not being more than one-half to three-quarters of an inch apart; yet, after the patient had been going about for a few weeks or months, there has been found a wide interval between them, owing to the gradual yielding or the sudden rupture of the new material.

Fig. 217.

Fig. 218.

Fig. 217. Fracture of the patella, united by ligamentous tissue. (From the Westminster Hospital Museum.)

Fig. 218. Fracture of the patella; the band of union passing from the periosteal surface of the upper to the articular surface of the lower fragment. (From St. Thomas's Hospital Museum.)

Hamilton examined a patient who had had his patella fractured nine weeks before, and found the fragments united by a short ligament, except on the inner side, where there was a separation or rupture of the ligament to the extent of a quarter of an inch. The patient explained this by saying that the splint was removed at the end of four weeks, and that after a week more, he began to walk, but that he almost immediately felt it tear or give

[1] Transactions of the Pathological Society of London, vol. xiii., p. 179.

way on the inner side. Dr. Coale also presented to the Boston Society for Medical Improvement "a specimen of a fractured patella taken from a man sixty-five years old, the fracture having occurred ten years before. The fragments were at first so closely united that no division between them could be discovered; but subsequently they became separated at their outer edges one inch, and at their inner edges one-eighth of an inch."[1]

The great rareness of bony union in transverse fractures of the patella is owing simply to the difficulty of keeping the fragments in sufficiently close apposition; when this is accomplished, bony union occurs as in other fractures. [An instructive case was presented to the Boston Soc. for Med. Improvement, Jan. 14, 1878, by the late Dr. J. B. S. Jackson, where bony union had been supposed to exist. "The union was so very close and firm that after removal, with all the force that could be used, not the slightest motion between the fragments could be felt, and it would have been regarded as a bony union, if it had not been either sawed or macerated. Three longitudinal sections, however, were made through the bone, and it was proved, so far as these would show, that at no point were the fragments united by bone. The union was as close as possible, but by a very dense and fibrous tissue that practically would be quite as serviceable as bone."—Boston Med. and Surg. Journ., May 2, 1878, p. 572.]

Treatment.—Three different plans have been adopted in this fracture; one consists in relying simply on the position of the limb, another in the immediate application of apparatus for bringing together the fragments, and a third in trusting to position only for the first ten or fourteen days, and then applying some approximate apparatus for the remainder of the period. The chief objection to the first plan is, that it is only applicable to those few cases in which there is but little or no separation of the fragments. In the majority of transverse fractures the fragments are more or less separated, and cannot be brought into contact with each other by mere position; so that the only question for consideration is, whether the apparatus for adjustment should be applied immediately, or be deferred till all inflammation and effusion into the joint have disappeared. The strongest argument in favor of immediate adjustment is derived from the fact that the extensor muscles go on contracting for some days after the fracture; so that not only is the upper fragment still further separated from the lower, but the muscles become so shortened that the fragments cannot be brought into contact with each other after the inflammation has subsided. On the other hand, if the inflammation in the joint is severe, the usual appliances for forcibly approximating the fragments would be injurious, and some delay seems absolutely necessary. The difficulty may be overcome by keeping the limb extended on a back splint, flexing the thigh and trunk on each other so as thoroughly to relax the rectus, and then acting on the fragments by strips of plaster placed diagonally from above downwards, and crossing each other on the splint behind; or the fragments may be acted on longitudinally by the method of Dr. Sanborn, of Lowell, U. S., who fixes a long strip of sticking-plaster, two inches and a half wide, in front of the limb, from the upper portion of the thigh to the middle of the leg, leaving at the knee a free loop. A bandage being applied above and below the knee, for the purpose of securing the plaster and controlling the circulation and muscular contraction, a small stick, six or eight inches in length, is put through the loop over the knee, and the plaster twisted until the fragments of the patella are brought into apposition.[1] [An ingenious and simple method of treating transverse fractures is that of Dr. Hornibrook (Phil. Med. Times, April 29, 1876, from Canada Lancet, Jan. 1, 1876.) The limb is placed on a straight posterior splint with the heel slightly elevated. The lower fragment is immovably fixed by adhesive plaster. Strips of the same pass longitudinally over the upper fragment to nearly the middle of the thigh. To the free end of this plaster a cord is attached passing over a pulley about two inches above the toes, and to this a two pound weight is attached. A bandage is applied over the strips, from the toes up, to prevent slipping. He reports three cases treated by this method, in all of which he claims to have secured "firm bony union." Hamilton (op. cit., p. 102), uses a splint of leather, or gum shellac cloth moulded to the limb, from the middle of the thigh to two or three inches from the heel. The foot is elevated six or eight inches. Bandages above and below to within three inches of the knee on either side confine the splint to the limb. A roller is then applied over the fragments, which are drawn together by an assistant. This third bandage commences above the upper fragment, then is carried below the lower, then, with oblique and finally circular turns over the fragments, the dressing is completed. As the bandage slackens it is stitched more tightly to the splint. Mr. Callender (St. Bartholomew's Hosp. Repts., vol. vi., Am. Jour. Med. Sciences, July, 1871, p. 214) disapproved of the inclined plane and ad-

[1] Coale, Boston Med. and Surg. Journ., vol. liv., p. 402.]

[1] Hamilton, On Fractures and Dislocations, [1st ed.], p. 443. [This excellent plan, though omitted by Hamilton in his later editions, is much used in the United States.]

vised the horizontal position. Subsequently, however (Med. Record, July 27, 1878), he treated the fracture with adhesive strips, obtaining counter-extension from a canvas slipper, approximating the fragments by pulleys, and allowing the patient to walk about. In the Pennsylvania Hospital Malgaigne's hooks are chiefly relied upon and have produced good results, but we must say that it seems a barbarous instrument.] Or belts of leather may be fastened above and below the patella, and then made to approximate by longitudinal straps; or the figure-of-eight bandage with a starched bandage outside may be applied; or Eve's ring;[1] or Malgaigne's hooks, which "consist of two steel plates, each an inch long and two-thirds of an inch wide, sliding upon one another, and this sliding regulated by a screw; the free extremity of each is bifurcated, and recurved into two very sharp hooks; the two hooks of the lower plate, only one-third of an inch apart, are intended to be inserted at the apex of the patella, which is lodged between them; those of the upper plate, which are to catch on the base of the bone, may be separated by a space twice as wide; and the inner one should also be longer than the outer by one-sixth to one-fifth of an inch, to make up for the obliquity of this end of the bone."[2] The action of this instrument is evident.

The chief defect of all these contrivances is their tendency to tilt forwards the fractured edges of the patella, causing them to gape in front, and so counteracting the intention for which they were applied; with a little mechanical skill, however, this may generally be overcome, and good ligamentous, if not bony, union obtained.

The average period for which retentive apparatus should be applied is from thirty-five to forty days; if it be removed earlier, or if the patient go about too soon, or if the fragments have not been properly adjusted in the first instance, the intervening ligament will be long and weak, or union may be wanting altogether. On the contrary, a too prolonged confinement of the limb is apt to terminate in permanent stiffness. It is pretty generally admitted, that the shorter the connecting medium between the fragments, the stronger and the more useful will be the limb; but the degree of restoration of which this is capable, in cases of non-union, or of an elongated uniting ligament, is a point on which there is much difference of opinion. The writer's experience leads him to regard complete restoration as exceedingly rare, and the general insecurity under which the subjects of such accidents labor is proved by the frequency with which they fracture their other patella; so that it may be safely affirmed, that a person who has had the misfortune to fracture one patella, becomes thenceforth prone to a repetition of the accident in his opposite limb. For these reasons it is advisable to wear a knee-cap, or some other apparatus which shall support, and, at the same time, limit the movements of the knee-joint.

The treatment of vertical and oblique fractures of the patella does not differ materially from that required for transverse fractures of the bone. The limb must be placed in the extended position on a Macintyre's splint, and, when the inflammation has subsided, the fragments must be brought together by firm pads, applied on each side of the bone, and fixed there by straps and the starch bandage.

[1] This ring was used by Dr. J. G. Fleming, of Glasgow, many years ago, and its construction and mode of application are described by Dr. Gibson in the Lancet of July 20, 1867.

[2] Malgaigne, op. cit., p. 779.

Fractures of the Leg.

Causes and pathology.—Although each of the bones of the leg may be fractured separately, it is most common to find both broken; and the above term is usually restricted to this injury. The reason of the greater frequency of fracture of both bones than of either bone singly, is probably owing, as Mr. Lonsdale has suggested, to the fact that a force sufficient to break the tibia is generally sufficient to extend to the fibula afterwards, and so to break it; whereas it must be a peculiar kind of force to break either the tibia or fibula singly.

Of 289 fractures of the leg admitted into the Middlesex Hospital between the years 1731 and 1837, 197 were of both bones, 51 of the fibula, and 41 of the tibia.[1] [According to Agnew's Tables (op. citat., p. 980), of 8667 fractures treated in the Pennsylvania Hospital, 2315 were fractures of the leg, and of these 1441 were of both bones, 437 of the tibia alone, and, singularly enough, an equal number, 437, of the fibula alone.] The extreme rareness of these fractures in infancy and childhood is a remarkable fact, especially when contrasted with the great frequency of fractures of the femur at this period, and the still greater frequency with which they themselves occur in after-life.

Of 515 cases collected by Malgaigne, but 1 was four years old, and only 12 were met with between five and fifteen years of age.

The causes of fracture of the leg are either direct, as the passage of a wheel over the limb; or indirect, as in slipping down or jumping from a height. The relative frequency of these causes in the production of this fracture has been variously estimated by different writers. Hamilton considers that four-fifths of them are caused by direct

[1] Lonsdale, op. cit., p. 19.

violence. The writer's experience is more in accordance with that of Malgaigne, who in 67 fractures of the leg, found 36 produced by direct violence, and 31 by indirect. Fractures from direct violence may of course be produced at any part of the bone, while those from indirect force mostly occur at the weakest part, that is, at the lower third, and they are extremely rare at the upper part of the bone.

The most frequent situation of fracture of the leg is where, from the greater weakness of the tibia, one would expect to find it, viz., in the lower third; so that of 155 fractures, from all causes, recorded by Hamilton, 93 occurred in this situation, 45 in the middle third, and only 11 in the upper third. [Agnew (as above) found that of 246 fractures of the tibia, 120 were in the lower third, 81 in the middle third, and 45 in the upper third.] The fibula is rarely broken at the same level as the tibia, but at a variable distance above it; most frequently, from two to three inches above it. Fractures of the leg present every variety of this injury which is met with elsewhere; but, from the superficial position of the tibia, comminuted and compound fractures are more common than in any other part of the body.

[Fig. 219.

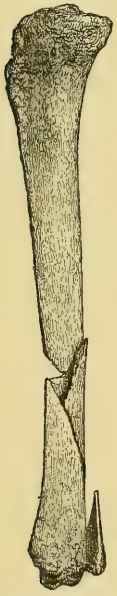


Fig. 219. Oblique fracture of tibia (Bryant).]

In the neighborhood of the knee- and ankle-joints, owing to the great force which is required to break the bones, these forms of fracture prevail; it has also been observed that the direction of the fracture in these situations is prone to be vertical, and so to implicate those joints. The prevailing direction of simple fractures of the leg is oblique, with the obliquity downwards and inwards, and generally slightly forwards; less frequently it is downwards and outwards, and still more rarely downwards and backwards. [Dr. Hodges presented to the Boston Society for Med. Improvement, June 13, 1870, a specimen of the V-shaped fracture of the tibia first described by Gosselin. "It occurs usually at about the junction of the middle and lower third. Both tibia and fibula are broken, but the fracture of the fibula is of secondary importance. The break in the tibia is neither transverse, oblique, or dentated, but spiral, both upper and lower fragment presenting the form of a V, the apex of which points downwards; from the apex of the V in the lower fragment a crack runs downwards, either spirally or obliquely, but always in the same general direction, and winds around the shaft, until it reaches the tibio-tarsal articulation, into which it enters." "The fracture is generally recovered from, but a long time is required for its consolidation; and a stiff ankle is pretty sure to supervene."—Bost. Med. and Surg. Journ., Aug. 18, 1870, p. 102. See also a paper by Dr. Hodges on "Fissures occurring in long bones; with remarks on V-shaped fractures of the tibia," in the same journal, Jan. 11, 1877, p. 33.]

Displacements of the broken bones may take place in these as in other fractures, and from the same causes; not unfrequently, however, there is no displacement, as in some transverse fractures; and it may be stated generally, that the more nearly the fracture approaches a transverse direction, and the nearer it is situated to the upper end of the bone, the less will be the liability to displacement, and the less its amount should it occur; indeed, in transverse fractures of the tibia, although the fragments may form an angle with each other, or the lower fragments be rotated outwards or inwards, they rarely become completely disengaged. In oblique fractures, on the contrary, there is nearly always overlapping, sometimes to a considerable extent, as when the fracture is caused by a fall on the feet from a height; for here the force being more than sufficient to break the bones, continues to act, and so displaces them. Should, however, the whole of the force be expended in causing the fracture, the subsequent displacement of the fragments is usually not great, and affects almost exclusively the lower fragment, which is drawn upwards, generally behind the other, but having an inclination to the inner or outer side, according to the direction of the line of fracture which regulates it; thus, the prevailing direction of the oblique fracture being downwards, inwards, and forwards, the displacement will be upwards, outwards, and backwards. Combined with this, there is often some rotatory displacement of this fragment outwards, due probably to the weight of the foot, and its tendency to gravitate in this direction. Accordingly in 19 specimens of united fracture of the bones of the leg, examined by Mr. Shaw, 16 had the lower fragment rotated outwardly, and situated somewhat to the outer side, and behind the upper.[1]

Symptoms and diagnosis.—There is rarely much difficulty in detecting a fracture of the leg, the superficial position of the tibia rendering any deviation from its normal form and direction evident. When the fracture is oblique, there is shortening

[1] Path. Soc. Trans., 1848–9, p. 125.

of the limb from two or three lines to three-quarters of an inch, and often more or less projection of the lower end of the upper fragment. In those cases, however, in which the fragments remain *in situ*, or in which there is much swelling, the nature of the injury may be overlooked; but the history of the accident, the sensations

Fig. 220.

FIG. 220. Displacement of foot backwards in a transverse fracture of the leg just above the ankle. (From a cast in the Museum of the Westminster Hospital.)

Fig. 221.

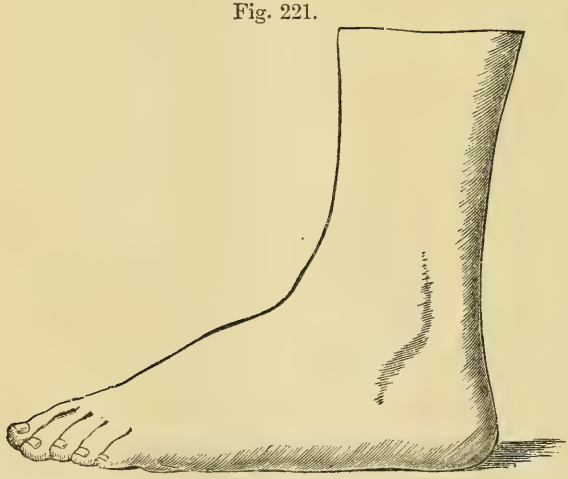


FIG. 221. Cast of healthy foot from the same patient to contrast with the above.

of the patient, his inability to support himself on the fractured limb, the mobility at the seat of fracture, and the crepitus on rotation, cannot fail to demonstrate its true nature. When the fracture is situated just above the ankle-joint, it is very liable to be followed by considerable displacement. If the direction of the fracture be transverse, the lower fragments with the foot will be drawn backwards, and so resemble a dislocation of the foot in that direction (as seen in FIG. 220). If the fracture be oblique laterally, the upper fragments slide down upon the lower and produce an apparent distortion of the foot, either inwards or outwards, according to the direction of the obliquity. These fractures with displacement must be distinguished from true dislocations accompanied with fracture; in the former the fracture is primary and the dislocation secondary; whereas the reverse is the case in the latter. In the displacements from fracture the articular surfaces of the tibia and astragalus maintain their normal relations to each other, and none of the ligaments of the joint are ruptured. In the true dislocations, the articular surfaces of the tibia and astragalus lose their normal relations, and some of the ligaments of the joint are ruptured. Then, as to the deformity which results from these accidents; in the true dislocations of the foot backwards, the malleoli are nearer the ground, whereas in the displacement from fracture they maintain their proper relations to the foot. The motions of the ankle-joint are lost in the former, they are preserved in the latter. In the lateral displacements likewise, though the foot may be situated outwards or inwards relatively to the leg-bones, its plantar surface rests flat on the ground, and not on its outer or inner borders, as in dislocation.

An interesting case of separation of the lower epiphysis of the tibia has been published by Professor Quain in the British Medical Journal, August 31, 1867. The subject of this accident was a healthy-looking lad, seventeen years of age, who, in dragging a piece of iron over a heap of earth, slipped and fell, his left foot being doubled under him. The lower end of the tibia projected forwards, and below the prominence there was a depression between it and the foot. The projection of the bonr was an inch and a half higher than the lowee margin of the fibula, and three-quarters of an inch above the lower edge of the malleolar process of the tibia. The space between the prominent tibia and the end of the great toe on the injured side, measured three-quarters of an inch less than in the other foot; the ankle-joint was uninjured; and Mr. Quain remarks

that this accident differed from a fracture of the bones above the ankle joint, in the absence of a sharp edge of a broken bone, and the smooth and rugous feel of the displacement, as well as in the absence of swelling occasioned by the effusion of blood. The bone was replaced without difficulty, and a starched bandage applied.[1]

Treatment.—All fractures of the leg are quickly followed by more or less swelling, and there are few simple fractures which it is not advisable to put up as soon after the accident as possible. If this be deferred, the swelling increases, the sufferings of the patient are prolonged, and the cure is rendered more tedious. The mode of putting up these fractures may be varied according to the nature of the case. In some, the fragments are in such good apposition, and there is so little tendency to displacement, that it is a needless cruelty to keep the patient in bed for five or six weeks. A starch or glue bandage may therefore be put on at once, and the patient allowed to get about on crutches a few days after the accident. In other cases, the local symptoms and the general condition of the patient may be such as not to admit of this kind of treatment. [In cases of oblique fracture near the ankle Montgomery recommends the application of extension by the weight and pulley. (Am. Journ. Med. Sci., April, 1871, p. 357.) Dr. S. W. Gross makes use of the same method in cases even where the obliquity is not marked. (N. Y. Med. Record, April 21, 1877, p. 246.) Dr. Robertson devised an exceedingly ingenious combination of extension by weight, with a modification of Smith's anterior splint, and a swing for those cases where riding of one fragment is a prominent symptom. It was used with excellent success in the Boston City Hospital. (See Boston Med. and Surg. Journal, May 23, 1878, p. 662.) Dr. Packard has also applied the principle of suspension to fractures of the leg, adapting it to the anterior splint and if desirable to the fracture-box. (See Am. Journ. Med. Science, April, 1874, p. 362.)] Thus if there should be much displacement or overlapping of the fragments, it will sometimes be found impossible to get them into place without first bending the thigh, leg, and foot at right angles with each other, and then making extension and counter-extension from the knee and ankle; and should there be a tendency to displacement of the fragments when the leg is straightened, it is advisable to keep the patient on his side with the limb supported between Sharp's splints, and well flexed so as to relax the most powerful muscles. This is also the easiest and most natural position for the patient to lie in, and it admits of a ready examination of the limb without disturbing it, by simply unbuckling the straps and removing the upper splint. To render this method of treating fractures of the leg perfect, the splint should have a second curve, at the upper part of the leg-piece, at right angles with it, and in an opposite direction to the lower, so as to embrace the knee-joint and lower third of the thigh. With such splints, firmly securing the joints above and below the fracture, no displacement or movement of the fragments on each other could possibly happen. Indeed, Hamilton is of opinion that this, which is Pott's method slightly modified, is the best, and is applicable to nine-tenths of all simple fractures, and to some compound. In these it is necessary for one of the splints to be interrupted, and an ingenious modification of the ordinary interrupted splint has been invented by Dr. Skipton; the essential feature of which is, that it consists of several pieces, any one or more of which can be removed, so that no matter in what part of the leg the wound may be, the same splint will serve. When the fracture admits of being put up in the straight position, it is preferable in my opinion to do so, and for this, almost any of the splints or apparatus ordinarily in use will answer the purpose. [The fracture-box is a very common and popular method of treating fractures of the leg in the leading hospitals in this country. Our own experience, however, has led us to be extremely partial to plaster dressings in the treatment of these fractures. Ahl's felt splints offer a convenient and ready method of applying a splint, which has for its characteristics lightness, firmness, and adaptation to the limb.] The points to be attended to in their application, are—1, to secure the knee and ankle-joints so that no axial rotation of the fragments shall take place; 2, to see that the foot is at right angles, or nearly so, with the leg; 3, that the ball of the great toe is in a line with the inner border of the patella; and 4, that there is no shortening of the front part of the foot from the sinking back of the heel. In the last edition of this work I spoke of Neville's splint as a very efficient and simple kind of apparatus in use in St. Bartholomew's Hospital, and in the Lancet of February, 1868, will be found an excellent practical lecture by Mr. Paget, in which the details of its application are fully described.

It consists of a back and two side splints. The back splint is a long and nearly flat piece of iron; bent at a right angle for the foot, and

[1] Preparations showing separation of the epiphyses of the lower end of the tibia and fibula, have been exhibited by Mr. Holmes, and are published in the Path. Soc. Trans., vol. xiii., p. 187. See also Diseases of Children, 2d edit., p. 236; New Sydenham Society's Biennial Retrospect for 1867–8, p. 258.

having two short cross-bars projecting from its side and looped to receive slings; its breadth is three and a half inches at the broadest part, and two and a half at its narrowest. It has an opening for the heel, and is slightly curved from above downwards, to correspond with the natural curves of the limb, and should be long enough to extend nearly half way up the thigh. The side-splints are of wood, and flat, and should be long enough for the ends to project a little beyond the foot-piece, and to reach to some three or four inches above the patella, and broad enough to enable the straps that are put round them completely to encompass them without touching the leg. These splints, well padded, are secured in their place without the use of the ordinary bandage; the foot, which should touch the foot-piece by the three balls of the sole, is held there by gutta-percha moulded to the dorsum, separated from the skin by a layer of flannel, and coming over the edges of the foot-piece, is fastened there with tapes or string. The side-splints are held together by a similar contrivance of gutta-percha moulded to the knee, and secured by straps and buckles. They are further held in place by two transverse bands, which buckle across their lower end beyond the foot-piece. The limb is then slung in a simple cradle, and at the end of three or four weeks, if the fracture be simple and uncomplicated, it is put in a plaster-of-Paris bandage. The only other apparatus that need be specially named, is that of Hester, of Oxford, which well fulfils all the indications above pointed out.

The treatment of compound fractures must depend entirely upon the amount of injury. The slightest form is that which occurs subsequent to the accident that caused the fracture, as when the upper fragment is thrust through the integuments on moving the patient, or when the skin ulcerates over a projecting fragment. For these nothing more is necessary than to restore the bone to position, and seal the wound hermetically with collodion and oiled silk, or with Lister's dressing of carbolic acid, described below. A more severe form is that which takes place at the moment of the accident, as in falls on the feet from a height, when the weight of the body forces the upper fragment through the skin. In these it is sometimes difficult, and even impossible, to reduce the fracture without enlarging the wound, or even sawing off a portion of the projecting bone. But when we have succeeded by these means in placing the fragments in apposition, the edges of the wound may be brought together and sealed hermetically, as above directed. The worst forms of compound fracture are those produced by direct violence, as the passage of a heavy wagon or railway-car over the limb. And in these there is usually so much injury and destruction of the soft parts as well as of the bones, that immediate amputation is the only proper course to pursue. In other cases, although there may be extensive comminution of the bones and laceration and bruising of the soft parts, as in kicks from a horse, an attempt should nearly always be made to save the limb.

Perhaps the best guide to the treatment of bad compound fractures is to be found in the amount and importance of the soft parts left uninjured by the accident. If the temperature and sensation of the foot are perfect, we may be sure that the principal nerves and bloodvessels of the limb are uninjured, and that they will be sufficient for the repair of the injury; whereas under contrary conditions, its salvation can hardly be looked for. There is a variety of simple fracture (using that term to signify a fracture without breach of the integuments) quite as bad as the worst forms of the compound, and equally with them calling for immediate amputation. It is that in which all the structures, except the skin, are completely crushed and pulpified. [The writer saw about a year ago a case of multiple comminuted fracture, where the muscular tissues seemed to have been but slightly injured, but the subsequent course of the case showed that the vessels had been lacerated and amputation became necessary.] When the attempt to save the limb is determined on, the wound must be cleansed, all foreign bodies or loose fragments of bone removed, the bones brought into the best position, and such an apparatus selected as will admit of the ready dressing of the wound without disturbing the fracture. One of the best for this purpose, is Macintyre's splint, as improved by Liston. Before any dressings are permanently applied, care must be taken that all bleeding has ceased, and until then, the wound should be left open. I have seen compresses put on to stop venous hemorrhage divert the blood from the exterior to the interior of the limb, and so cause extensive extravasation beneath the skin and among the muscles. The subsequent treatment may then be conducted on general principles, as laid down in the essays on wounds and fractures. [We find, as has been heretofore stated, that plaster-of-Paris is invaluable in the treatment of this class of cases. With metallic strips the splint can be made light and strong,—the strips can follow almost any direction, straight or spiral, and there is hardly any limit to the size of the fenestra that can be cut. With a splint thus reinforced with Markoe's system of thorough drainage (see Am. Jour. Med. Sci., April, 1880, p. 305) and his modified Listerism, we think the treatment of compound fracture is as nearly perfect as it well can be with our present knowledge.] This section would, however, be incomplete without alluding to the antiseptic principles of treatment introduced by Professor Lister, and strongly advocated by Professor Syme. The theory of the practice may be enunciated in the following propositions.

1st. All the local inflammatory mischief and general febrile disturbance which follow severe injuries, are due to the irritating and poisoning influence of decomposing blood or sloughs. 2d. This decomposition is owing to the presence of minute organisms suspended in the air. 3d. To prevent this decomposition, with its attendant evils, it is necessary to apply as a dressing to wounds, some material capable of destroying the life of the floating particles. 4th. Carbolic acid, from its destructive influence on low forms of life, is the most powerful antiseptic with which we are acquainted, and hence the most proper dressing for wounds.

The preparations employed by Mr. Lister,[1] are the carbolic oil, carbolic lotion, and carbolic paste. The composition of the first is, carbolic acid one part, boiled linseed oil five parts; that of the second, carbolic acid one part, water twenty parts; and that of the third, carbolic oil, with whitening in the proportions requisite to form a soft putty. In the treatment of bad compound fractures of the leg, Mr. Lister first swabs all the recesses of the wound with a piece of rag dipped in strong carbolic acid; a rag dipped in carbolic oil is then placed over the wound, and maintained there permanently; while the paste is laid on outside this, and overlaps the sound skin for a considerable distance. "The putty should be in a layer of a quarter of an inch thick, and may be advantageously applied rolled up between two pieces of thin calico." To prevent evaporation of the acid, the paste should be covered with tinfoil strengthened with adhesive plaster. As long as any discharge continues, the paste should be changed daily, but when it has ceased, it is discontinued. The original oiled rag is left adhering to the skin, till healing by scabbing is supposed to be complete. [For a more full account of the various methods of applying the antiseptic method of treating wounds, and for the modifications that have been introduced by Mr. Lister himself, we refer the reader to the article on Operative Surgery.] At a later period of the treatment, it is sometimes desirable to release the patient from the position which was adopted in the first instance, and to swing the leg in a cradle, of which one of the best is that of Mr. James Salter.[1] | Dr. Van Wagenen, while house surgeon at Bellevue Hospital, devised an extremely simple and cheap method of suspending the leg, which leaves little to be desired. It consists of an elbow of wood projecting over the foot of the bed, from which the leg is suspended by two pieces of rubber tubing; one above the ankle, the other just below the knee. "The tubes have common grooved iron pulleys or wheels at each end. Those above rolling on a large iron wire" (in slots cut in the horizontal) "to allow motion towards the head or foot of the bed; those below at right angles to the others, holding the rings of rope in which the leg rotates, this last being by far the most important, allowing the patient to turn on either side." The screw of the pulley is pushed into the tube and fastened by a few turns of fine copper wire, and a bit of bent wire acts as a shield over the pulleys running in the slot, and sustains the weight of the bedclothes. (See Med. Rec., April 1, 1873, p. 145).] This differs from all others in the greater freedom of movement it allows to the patient without risking the disturbance of the fracture.

Fig. 222.

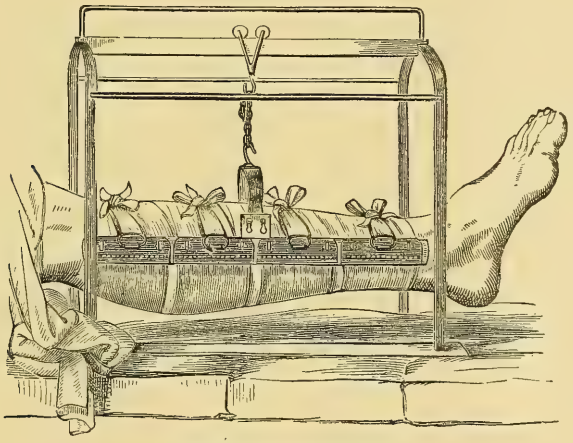


Fig. 222. Salter's Swing.

Fractures of the fibula.—Any part of this bone may be broken by direct violence, and the fracture be unaccompanied by displacement or other injury; but most frequently the bone yields to indirect force, at a point from two to four inches above the

[1] See British Medical Journal, Sept. 21, 1867; also Jan. 4, 1868 [and many later articles].

[1] "On a New Swinging Apparatus for the Treatment of Fractures of the Leg," by S. James A. Salter, M.B., etc., in Provincial Med. and Surg. Journal, 1850, p. 564.

extremity of the malleolus, and this is accompanied by a partial dislocation of the foot.

The accident is caused either by a sudden twist of the foot, outwards or inwards, or by its becoming fixed in the cleft, and the body, falling to one or the other side, as in the well-known case of Sir Astley Cooper, who fractured his right fibula by falling on his right side while his foot was entangled between two pieces of ice.

As to the relative frequency of the causes which produce the fracture: of 200 cases which came under the observation of Dupuytren, 20 were the result of direct violence, 60 were produced by forcible eversion of the foot, and 120 by forcible inversion. The greater frequency of this injury from indirect violence than from direct is generally admitted; but in the experience of English surgeons, eversion of the foot is a more frequent cause of this fracture than inversion.

Hamilton, in a record of 32 fractures of the fibula, was able to ascertain the cause satisfactorily in 18. Of these, "3 were the result of falls directly upon the bottom of the foot, 4 of a slip of the foot in walking on level ground, or on ground only slightly irregular; and 12 (query 11) of direct blows. In all of the fractures which have been produced by falls on the bottom of the foot, and in all except one produced by a slip of the foot, the accident was accompanied with a dislocation of the ankle, the foot being turned outwards."[1] In 7 also of the 11 (?) produced by direct blows, the tibia was thrown more or less inwards and the foot outwards. These 18 cases in which the cause of the fracture is said to have been ascertained, are obviously too few to invalidate the general belief in the greater frequency of indirect than direct fractures of the fibula; neither is it credible that a fall flat on the foot without a subsequent twist of it, or what amounts to the same thing, an inclination of the body to one side, could fracture this bone. To produce such a result, there must be a change in the direction of the line of transmission of the weight of the body from the tibia to the fibula. In the fracture from eversion, the internal lateral ligament is frequently torn through, and even the inner malleolus fractured; but in the fracture from inversion, the external lateral ligament remains entire, and probably contributes to the fracture, the bone yielding to the pressure of the astragalus against the external malleolus.

Displacement of the foot does not necessarily follow a fracture of the lower third of the bone, even when caused by indirect violence; and Malgaigne affirms, with much positiveness, that in the majority of fractures by adduction there is no displacement whatever, and that when it occurs, it is secondary, and owing to the patient's attempt to walk; when the foot becomes turned outward, as in the fracture from abduction. Even when produced by the latter cause, he affirms, there may be no appreciable displacement. Hamilton, on the contrary, as before quoted, found displacement in all but one of his indirect fractures, and in all but three of the direct; while Dupuytren asserts that nine-tenths of his fractures were attended with displacement. It is probable that Dupuytren has as much exaggerated the frequency of the subsequent dislocations as Malgaigne has underrated their frequency. With reference to the obliquity and the position of the fragments, it may be stated, generally, that fractures from indirect violence are usually more or less oblique, and those from direct, transverse; and that when displacement of the foot occurs, as a consequence of the fracture, the broken ends of the bone will project inwards towards or even against the tibia. [Mr. Wagstaffe, in St. Thomas's Hospital Reports, New Series, vol. 6, reports two cases of vertical fracture of the fibula "in its lower end, with a displacement of the fractured portion in such a way, that it was twisted round on its long axis." One patient died suddenly a few hours after admission and it was found "that, in addition to a transverse fracture two inches above the malleolus, there was a piece of the fibula broken off longitudinally, which involved one-third of the breadth of the bone, and was so twisted upon itself that its upper end rested upon the tibia, which displacement it was found practicable to reduce by manipulation." In the other case the displacement was not reduced, the parts became firmly united in their deformed position, and the patient walked with difficulty. (See Am. Journ. Med. Sciences, April, 1877, p. 471).]

Symptoms.—A fracture of the fibula, unless attended with displacement of the foot, cannot be recognized by any external sign, for the fragments are kept in apposition by the tibia, and there is, consequently, no deformity; while ecchymosis, if present, may exist independent of fracture. The best means of detecting the fracture is by grasping the leg with both hands, and with the thumbs making alternate pressure on the bone immediately above and below the suspected fracture, when, if it exist, motion and crepitus will at once be felt; or, if the fracture be situated just above the malleolus, the lower fragment may be acted on by forcibly inverting and everting the foot, while the thumb of the other hand is placed over the fracture; the characteristic signs will thus be elicited. [Keen (Phil. Med.

[1] Hamilton, op. cit., p. 453.

Times, Aug., 15, 1872, p. 426) gives a diagnostic mark of great value, viz., the increased space between the malleoli, from the external having lost its support, the lower fragment being tilted in towards the tibia. If this is not apparent it can be made so by a lateral movement of the astragalus. This movement could not be made except in the condition of fracture of the fibula. Care must be taken that it is the astragalus, which is "moved laterally, and not the *foot* itself *twisted* internally."]

Treatment.—For a simple fracture of the fibula in its upper two-thirds no treatment besides rest is necessary; but in the lower third of the bone the application of some apparatus is advisable, even should the fragments not be displaced. Nothing is better for this purpose than the starch bandage, strengthened by pasteboard splints, on the inner and outer sides of the foot and ankle, care being taken that no displacement occurs during their application, or while the apparatus is drying. In those cases of fracture accompanied with marked displacement of the foot, and therefore with rupture of the internal lateral ligament (Pott's fracture),[1] Pott's method may be adopted. This consists in placing the patient on his injured side, with the knee bent and the foot somewhat inverted, so as to insure the broken ends of the bone being in contact with each other, and not with the tibia. A Sharp's splint, well padded, and having the pad for the foot-piece thicker than that for the leg, so as to raise a little the outer border of the foot, should next be applied on the outer side of the limb; and, for greater security, an inner splint without a foot-piece may also be placed on the inside of the limb. Dupuytren considered that Pott's method was insufficient to maintain the reduction, and directed the foot to be brought into such a state of adduction as that its inner edge should become superior, its outer edge inferior, and its sole directed inwards. For this purpose he employed a wedge-shaped cushion, the thick end of which is downwards and applied upon the inner malleolus; over this a splint was laid, which reached from the knee to three or four inches beyond the edge of the foot; the leg being then secured to the splint, the foot was next drawn inwards, and firmly fixed to the projecting end of the latter. The principle of this method is to make the foot act as a lever on the lower fragment of the fibula, so as to draw it outwards from the tibia, while at the same time the lateral pressure fixes the astragalus firmly against the inner malleolus. [We think that even here plaster-of-Paris splints give excellent results.]

The period for which any apparatus should be kept on will depend on the situation of the fracture, and the injury done to the ankle-joint. In fractures of the upper part of the bone, it has been already stated that no application is necessary; but in the lower part, even should there be no displacement, splints should be kept on for three or four weeks; and in case of a dislocation of the foot, for six weeks or two months. In all fractures of the fibula in its lower third, great caution should be observed in using the limb after the removal of the apparatus, and it may be well to support the joint for some time by a laced boot, strengthened on the inner side; the sole should also be made somewhat thicker on its inner than its outer edge.

Fractures of the tibia.—A direct blow on the tibia, as a kick, will sometimes break this bone without the fibula, and the fracture may be situated at any part, or take any direction; it is, however, more commonly met with in the upper than in the lower half of the bone, and is more frequently transverse in direction than when accompanied with fracture of the fibula; this circumstance, together with the integrity of the latter bone, renders displacement of the fractured ends almost impossible, and the diagnosis of the injury is thus oftentimes obscure. "In some kind of fractures near to the ankle-joint, when the injury is caused by a fall, and not by a direct blow, there may be displacement, although the fibula remain entire; for the weight of the body will continue the force onwards after the tibia is broken, and so produce a distortion in the position of the foot and ankle-joint, according to the direction in which the force is applied. Thus, in a fracture of the lower end of the tibia, about an inch or an inch and a half above the ankle, that portion of the bone connected with the astragalus will move in whatever direction the foot is forced, and so may be twisted upon the shaft of the bone, or pushed backwards or forwards to a sufficient extent to produce a marked distortion."[1] When, however, from the absence of all displacement of the fragments, the existence of fracture is doubtful, it may be suspected if pain constantly persists in one part of the bone, if this pain be increased by pressure, and, above all, by bearing any weight on the limb; but to convert suspicion into certainty, the limb should be firmly grasped above and below the suspected fracture, and attempts made to bend it; by its yielding to, or resisting the force applied, we ascertain whether it is broken or otherwise.

Treatment.—Of all the fractures of the lower extremity, this is perhaps the best adapted for the immovable apparatus, the

[1] See p. 980.

[1] Lonsdale, On Fractures, p. 110.

application of which, *mutatis mutandis*, may be made in the same way as directed for fractures of the femur.

Mr. J. Gillingham, of Chard, claims to have invented an instrument with which he has had great success in procuring the union of ununited fractures of the leg. In the case of a "fat heavy man" the bones remained ununited two years and a half after the accident, yet in nine months after wearing this instrument, the union was so firm that he could walk several miles, and was able to follow his ordinary occupation as a laborer. The instrument can be equally adapted to ununited fractures of the femur. It consists of, first, a collar, which is moulded to the leg just below the knee, and on each side of which is a stud; secondly, of a boot with a socket at the heel; and, thirdly, of two steels, with ankle-joints bifid at the top to catch the studs on the collar, and capable of elongation or shortening, as seen in the engraving. Thus the weight of the body is taken off the leg-bones, and transmitted down the two side-steels. Mr. Gillingham assures me that patients are able to walk without crutch or stick, immediately the instrument is put on.

Fig. 223.

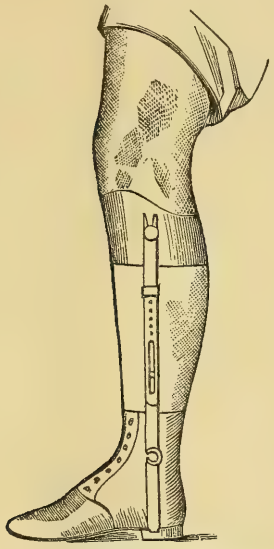


FIG. 223. Mr. Gillingham's instrument for ununited fracture of the leg.

Fractures of the Foot.

These are most frequently caused by heavy bodies falling upon it or crossing over it, and so crushing it: hence the soft parts also are not unfrequently lacerated, or contused to such an extent as to require the removal of a part, or the whole, of the member; if, on the contrary, the soft parts are not much injured, rest and support, together with evaporating lotions, constitute the only treatment necessary.

The only bones of the tarsus the fractures of which require special notice are the astragalus and os calcis. The fracture of the former, according to Malgaigne, is always caused by a fall from a height, and it is often the only tarsal bone which is broken, while in a general crushing of the tarsal bones, it nearly always escapes injury. The direction of the fracture is various, though most frequently it is through the neck of the bone, and, unless compound, cannot usually be detected; in the latter form of injury, the portion displaced should be returned, or, if completely isolated, removed.

The os calcis may be broken either by crushing, falling from a height on the heel, or by muscular action. Malgaigne considers the latter mode of fracture problematical; he could find only eight cases recorded, and most of them so loosely that they fall far short of proof. In two cases the fracture was said to have been the result of a false step; in one it was caused by the upsetting of a wagon; in five by falling from a height on the feet. The fracture is always situated behind the astragalus, and, we may presume, ought to be vertical in direction; but in the published accounts of this fracture this point is left in uncertainty. The extent to which the detached fragment is drawn up by the gastrocnemius and soleus has been found to vary from almost nothing to five inches; a difference which is probably owing to the part at which the fracture has taken place, and whether the posterior fragment is completely isolated from the rest of the bone, or is partially connected with it by the fibrous structures in the sole. The nature of the injury is easily detected by examination; in addition to the pain, swelling, and deformity, the detached portion can be felt, and its relative distance from the heel will be lessened or increased by extension and flexion of the foot. The treatment consists in subduing the inflammation and keeping the foot extended and the leg flexed, by any of the contrivances made use of in rupture of the tendo-achillis. In fractures by crushing, the symptoms are more severe, the pain, swelling, and ecchymosis greater, and the crepitation more obscure; the two most characteristic signs are, increased width of the heel, and lowering of the arch of the foot. This fracture has been mistaken for a sprain, and for a fracture of the fibula without displacement, from either of which it may be distinguished by the above-mentioned symptoms and a careful manual examination. Consolidation takes place slowly, and it is often several months before the functions of the foot and ankle are restored.

The best method of treatment consists in placing the limb on its outer side, on a Sharp's splint, till all the acute symptoms

have subsided, when some of the forms of the immovable apparatus may be substituted, and the patient allowed to go about on crutches. The apparatus should be worn for two months before attempting to use the foot. Fractures of the metatarsal bones and phalanges are always the result of direct violence, and, if simple, require no treatment but rest, and the ordinary remedies to subdue inflammation. If compound, the treatment must be regulated by the number of bones fractured, their degree of comminution or displacement, and the condition of the soft parts; if the latter are not bruised beyond recovery, and if the former can be replaced, and the constitution of the patient is good, an attempt should be made to save the foot. Under opposite circumstances, the injured parts should be removed, care being taken to leave as much of the sound portions as shall insure a useful stump.

Dislocations.

Dislocations of the Hip.

The head of the thigh-bone, though lodged in a deep cavity, to which it is accurately adapted, and in which it is retained by atmospheric pressure, and by strong ligaments and muscles, is yet more frequently displaced than these physical and anatomical dispositions would seem to admit of. Indeed, if reliance is to be placed on the statistics of this accident collected by M. Malgaigne at the Hôtel Dieu, there is no joint of the lower extremity in which dislocation occurs so frequently as in the hip: next to the shoulder, it is the most liable to this accident of any joint in the body, as seen in the following table.[1]

In 491 cases of dislocation, there were—of the

Shoulder	321	Wrist	13
Hip	34	Fingers	7
Clavicle	33	Jaw	7
Elbow	26	Knee	6
Foot	20	Radius	4
Thumb	17	Patella	2
		Spine	1

This great proneness to displacement of the shoulder and hip-joints is doubtless owing in part to their extensive range of motion, and in part to the powerful leverage which may be exerted on them by a force applied to the distal extremities of the respective limbs, or of the humerus and femur. Dislocations of the hip are nearly always accidental, and result from the application of great force; hence, we should expect to meet with them most frequently in the male sex, and at the most active period of life; this is fully borne out by the accompanying table from Malgaigne. In fifty-one cases of dislocation of the hip, forty-two were males, and nine females; and the following were the ages of the sufferers:

At 3 years of age	1	From 45 to 60	10
From 15 to 20	8	" 60 to 85	5[1]
" 20 to 45	27		

[Of 115 cases collected by Hamilton,[2] 104 were in males and 11 in females; and in 84 cases the ages were as follows:

Under 15 years	15	45 to 60 years	7
15 to 30 years	32	66 to 85 "	1]
30 to 45 "	29		

In the 56 cases of this accident collected by Sir A. Cooper, the age of the patient is not stated in 11; but in the remaining 45, I find 7 were under 20 years of age, 7 were 50 and upwards, and 31 between 20 and 50.[3] The earliest recorded age at which a dislocation of the hip has occurred is six months: it was into the obturator foramen, and was easily reduced by manipulation.[4] Although dislocation of the hip cannot usually happen without the application of great force, individuals have been met with who possessed the power of voluntarily dislocating their hip, and again reducing it, as related by Sir A. Cooper,[5] Stanley,[6] and Brodie.[7]

Dislocations of the hip sometimes take place spontaneously, in consequence of paralysis of the muscles external to the joint, or from disease of the joint itself; they are also occasionally met with as congenital affections, due to causes acting in utero, or to violence inflicted during birth. In the present essay we have to treat of those dislocations of the hip which result from violence; and they occur most frequently in the following directions:

1st. The head of the bone is thrown upwards, and more or less backwards, upon the dorsum ilii.

2d. Backwards, and slightly upwards, or into the ischiatic notch.

3d. Downwards and inwards, or into the obturator foramen.

4th. Upwards and inwards, or upon the body of the pubes.

[One of the most important contributions to our knowledge of this subject is the now classical work of Professor H. J. Bigelow, of Boston ("The Hip," Phila., 1869).

[1] Traité des Fractures et des Luxations, 1855, tome ii., p. 8.

[1] Ibid., p. 805.

[2] Fract. and Dislocations, 6th ed., p. 739.

[3] On Dislocations and Fractures of the Joints, 5th edition, edited by Bransby B. Cooper.

[4] This unique case is recorded by Mr. Powdrell in the Lancet of 1868, vol. i., p. 617.

[5] Op. cit., Case 2.

[6] Vide Stanley, Med.-Chir. Transactions, vol. xxiv.

[7] Brodie, On the Joints.

In this the author draws special attention to the influence of the ilio-femoral or Y ligament (FIG. 224) upon the injuries now

Fig. 224.

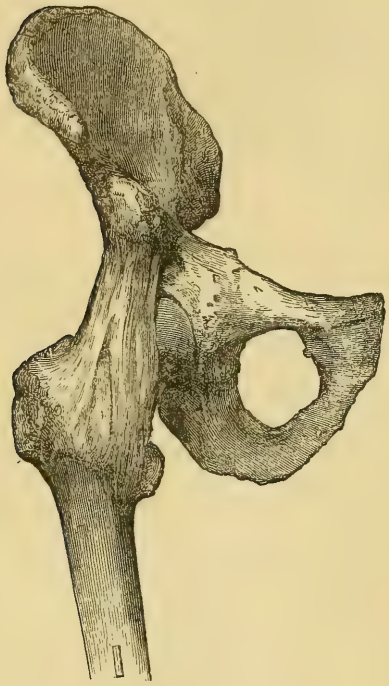


FIG. 224. Ilio-femoral ligament. (Bigelow.)

under consideration, which he divides as follows:

"I. The regular dislocations, in which one or both branches of the Y ligament remain unbroken.

1. Dorsal.	Both branches entire.
2. Dorsal below the tendon (ischiatic notch of Cooper)	
3. Thyroid and downward. Obliquely inward on the thyroid foramen, or as far as the perineum. Vertically downward. Obliquely outward as far as the tuberosity.	
4. Pubic and subspinous.	
5. Anterior oblique.	
6. Supra-spinous.	External branch broken.
7. Everted dorsal.	

"II. The irregular dislocations, in which the Y ligament is wholly ruptured."]

The proportion in which these dislocations are met with, are, according to Sir A. Cooper, the following: in 20 cases, there will be 12 on the dorsum ilii, 5 into the ischiatic notch, 2 into the obturator foramen, and 1 on the pubes. In 104 cases collected by Hamilton (excluding the anomalous dislocations), 55 were upon the dorsum ilii, 28 into the ischiatic notch, 13 into the obturator foramen, and 8 upon the pubes.

In the experience of Malgaigne, Chelius, and Fergusson, the dislocation into the obturator foramen is the most rare.

Occasionally, but very rarely, both hips are dislocated simultaneously. Hamilton (op. cit., p. 740) quotes two such cases, one from Gibson and the other from Schinzinger. T. C. Barker (Am. Jour. Med. Sciences, April, 1854) reports the case of a boy of 19 who had both femora dislocated into the thyroid foramina (the left thrust through into the pelvis) by a fall of 30 feet into a sand-bank. H. L. Prichard (ibid., July, 1854, from Association Med. Jour., April 21, 1854) records that of a boy of 15, who was "doubled up" under a truck and had both femora luxated upwards and backwards. Boisnot (Ibid., Oct. 1867) reports a dislocation of the right femur on the pubis, the left on the dorsum ilii. Mr. Pollard (St. Barth. Hosp. Rep., vol. 80, ibid., July 1873, p. 193) reports a case in which the left hip was dislocated upwards and backwards, and the right downwards and forwards into the thyroid foramen. Dr. Crawford, of Wilkesbarre (ibid., Oct., 1876, p. 409), also reports a case, in which the right was displaced upon the dorsum, and the left into the ischiatic notch. Allis (Trans. Penna. State Med. Soc., 1879) records a case in which the right femur was displaced on the dorsum ilii, the left into the thyroid foramen. Packard (Phila. Med. Times, July 17, 1880) gives an account of a man who was caught under a falling house, and had the left femur dislocated into the thyroid foramen, the right on the dorsum ilii.]

Besides the four ordinary dislocations of the hip, some anomalous ones have been described, of which mention will be made presently.

Pathology.—The injuries which are common to all the above varieties of dislocation, are laceration, and sometimes complete detachment of the capsular and round ligaments from the femur and the acetabulum, and a stretching or tearing through of one or more of the muscles which surround the joint.

[For a very able discussion of the subject of the present section we cannot do better than to refer the reader to the monograph of Professor Bigelow, already mentioned, which has become classical, and which goes over the whole ground more satisfactorily than any other treatise with which we are acquainted. To quote from it, as we would like, would transcend the province of an editor.]

1. *Dislocation upwards and backwards, or upon the dorsum ilii.*—In this dislocation

the head of the femur is thrown upwards, and more or less backwards, and will occupy different positions in different cases, as already observed. In one case it has been found lying partly on the bone, partly on the gluteus medius, and partly on the pyriformis muscle; in another, between the gluteus maximus and the posterior border of the gluteus medius; and in another, underneath the inferior border of the gluteus medius, by which it was fixed in its unnatural position. The small external rotator muscles of the hip are either put upon the stretch, or some or all of them may be torn across. With respect to the height to which the head of the femur may ascend in these iliac dislocations, Malgaigne found in 11 preparations of this accident which he examined, that in 5 it did not ascend higher than a line drawn from the anterior superior spinous process of the ilium to the highest point of the ischiatic notch; in two it ascended half a centimetre (about one-sixth of an inch) higher; in 2, 1 centimetre; in 1, 1 centimetre and a half; and in 1, 2 centimetres. The limits of the displacement below were never lower than the point of junction of the ilium with the ischium; but the limits posteriorly were somewhat greater.

[Fig. 225.

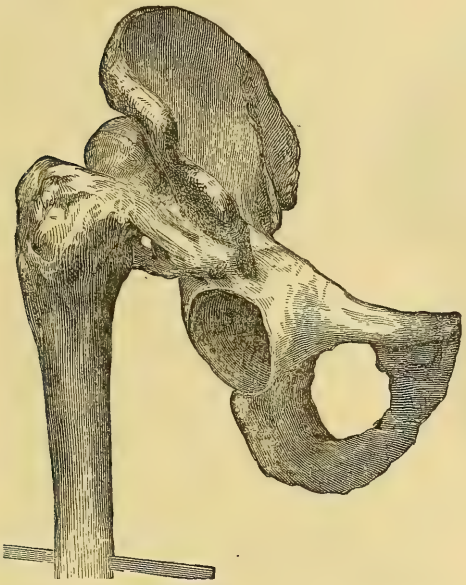


Fig. 225. Dislocation upon the dorsum ilii. (Bigelow.)]

[Fig. 226.

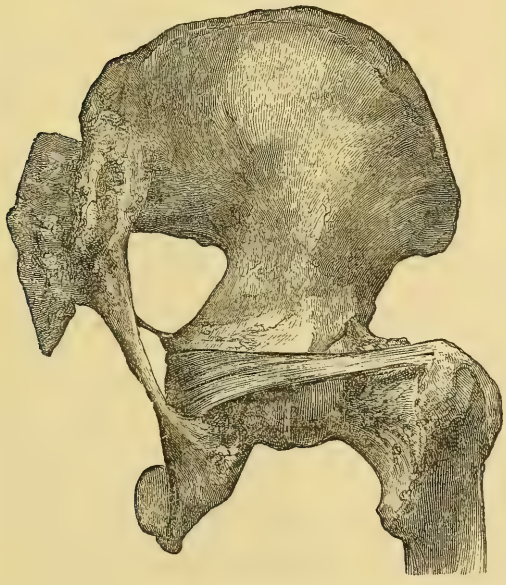


Fig. 226. Tendon of the pyriformis muscle. (Bigelow.)]

Symptoms.—The limb is from an inch and a half to two inches and a half shorter than its fellow; it is rotated inwards, adducted and slightly flexed; so that when the patient is standing, the knee of the affected side is somewhat in front of, and above the other, and the toes rest on the tarsus of the opposite foot; the great trochanter is directed forwards, and lies nearer to the anterior superior spinous process of the ilium than natural, while the head of the bone is directed backwards, and, in thin persons, may be felt lying upon the dorsum ilii. The only movement of which the limb is capable, unless great force is used, is a slight one in the sense of flexion, adduction and rotation inwards; its elongation, extension and abduction cannot be accomplished, and the attempt is productive of great pain.

2. *Dislocation backwards and slightly upwards, or into the ischiatic notch.*—In this dislocation, which is merely a variety of the former, the head of the bone is thrown slightly upwards, as well as backwards. Syme found the gluteus maximus nearly torn across, and the head of the bone imbedded in it was lying in the great ischiatic notch, upon the gemelli and the sacro-

sciatic nerve. The gluteus minimus, the pyriformis, and the gemellus superior were lacerated. The symptoms very closely resemble those of the dislocation upwards, but are less marked. [Bigelow says of this luxation, which he terms dorsal below the tendon, "The limb is extremely inverted. It crosses the opposite thigh, even as high as the middle of it, although in the upright position it may gravitate to a lower point. It is considerably in advance of the sound limb." (Op. cit., p. 62.)] Thus the shortening of the limb rarely exceeds half an inch; its adduction, inversion, and flexion are less; so that in standing the knee projects but slightly beyond the other, and the point of the great toe rests on the ball of the great toe of the opposite foot, instead of on the tarsus. [Mr. Annandale (Lancet, February 5, 1876,) reports a case of sciatic dislocation with *eversion* of the limb. (Philadelphia Med. Times, April 29, 1876, p. 382.)] The trochanter is somewhat behind and above its normal position, but remains nearly at right angles with the ilium, while the head of the bone is so buried in the ischiatic notch that it cannot be felt. The limb is fixed, and all voluntary movements are abolished.

[Fig. 227.

FIG. 227. Dislocation into ischiatic notch. (Bigelow).]

Causes.—These dislocations, according to Sir A. Cooper, are most commonly brought about by a fall whilst carrying a heavy load on the shoulders, or by a heavy weight, such as a mass of earth, falling on the back whilst the

Fig. 228.

FIG. 228. Dislocation of the hip on the dorsum ilii. (From Sir A. Cooper.)

Fig. 229.

FIG. 229. Dislocation of the hip into the sciatic notch. (From Sir A. Cooper.)

body is bent forwards in a stooping posture.

Diagnosis.—There is not much likelihood of either of these dislocations being mistaken for any other injury, though certain fractures in the neighborhood of the hip do occasionally resemble them. [Dr. Allis (Phila. Med. Times, March 28, 1874, p. 404), draws attention to a sure diagnostic sign of the dislocation of the sciatic variety. It consists in first measuring the limbs extended, when the shortening, if there is any, will not exceed three-fourths of an inch. "Next compare the limbs at right angles to the trunk, and if it be a sciatic dislocation there will be a difference of at least *one inch and a half; but if the measurements in both positions are the same, there cannot by any possibility be a sciatic dislocation.*" This depends upon the fact that in a horizontal position of the pelvis the sciatic notch lies an inch and a half below the acetabulum. "If one thigh is half an inch shorter than its fellow (as may be possible in impacted fracture) the same difference will persist in flexion, extension, abduction, or adduction. But not so in dislocation. Here the head of the bone is fixed at a point that does not correspond to the acetabulum, and in every new position, in which the limbs may be compared, a different result may be expected."[1]] Among these may be enumerated fractures of the neck of the femur, with inward rotation of the limb, especially if the fracture be complicated with one of the great trochanter; a portion of the latter may then be drawn by the action of the muscles towards the great sciatic notch, or upon the dorsum of the ilium, and so resemble the head of the bone in those situations, as, indeed, happened in the following case related by Smith, and which was at first mistaken for a dislocation.

The patient was an old man, eighty years of age, who died on the fourteenth day after the accident. During life the limb was shortened two inches, the foot inverted, and the entire limb in a state of adduction; the trochanter major could be felt upon the dorsum of the ilium, a little above the situation of the sciatic notch. After death, there was found a transverse serrated fracture of the neck of the femur external to the capsule; at the line of junction of the cervix with the shaft of the bone a second fracture detached the trochanter major, which was drawn upwards and backwards, carrying with it the insertions of the pyriformis, gemelli, and obturator muscles.[1]

Fig. 230 a. Fig. 230 b.

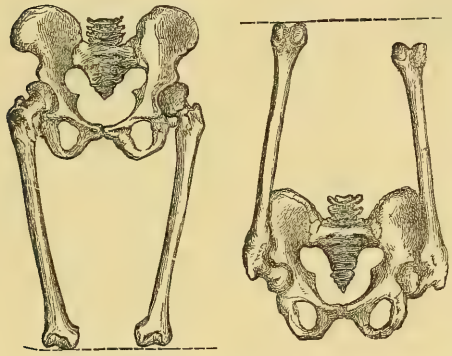


FIG. 230 a. Normal thighs and pelvis. 230 b. Dislocation into ischiatic notch. (Bryant.)

Another fracture which somewhat resembles these dislocations is that of the acetabulum, with shortening and inversion of the limb; [See a reference to two cases in the address of Mr. Favell before the British Medical Association, 1876. (British Medical Journal, August 5, 1876, and American Journal of Medical Sciences, October, 1876, p. 578.)] but in all these fractures the shortening can be overcome by traction, and recurs when this is remitted. There is also crepitus.[2]

Treatment.—In nearly all dislocations of the hip it will be advisable to bring the patient under the influence of chloroform [ether] before making any attempts at reduction, and as soon as this is effected, a long splint should be applied to the outside of the limb and trunk, and not removed for two or three weeks. There are two methods of reducing these, and the other dislocations of the hip—one by means of traction, and the other by manipulation. [We presume that nearly all American surgeons of the present day have recourse to manipulation, and very generally with success. Stephen Smith (Operative Surgery, p. 152) says: "The best general rule for reducing a recent dislocation is to get the head of the femur directly below the socket, by flexing the thigh at about a right-angle, and then to lift or jerk it forcibly up into its place. This rule applies to all dislocations except the pubic, and even to that when secondary from below the socket; the reduction by the lifting method is usually instantaneous, and flexion is the basis of its success. . . . In dorsal dislocations, flex and forcibly lift; if this effort fail, flex and lift while abducting. If this fail, it will be found that

[1] Although the cut from Bryant's Surgery bears the name of Dr. Dawson, it is but fair to state that Dr. Allis's paper preceded by four years that of Dr. Dawson.]

[1] Op. cit., Case 29, p. 85. See also similar cases by Stanley in vol. xiii. of the Med.-Chir. Trans., p. 504.

[2] For an interesting case by Mr. Birkett, in which a dislocation of the head of the femur was complicated with its fracture, the reader is referred to vol. lii. of the Med.-Chir. Trans.

abduction has carried the head of the bone from the dorsum nearly or quite to the thyroid foramen, and that the capsular rent has been so enlarged that the first

Fig. 231.

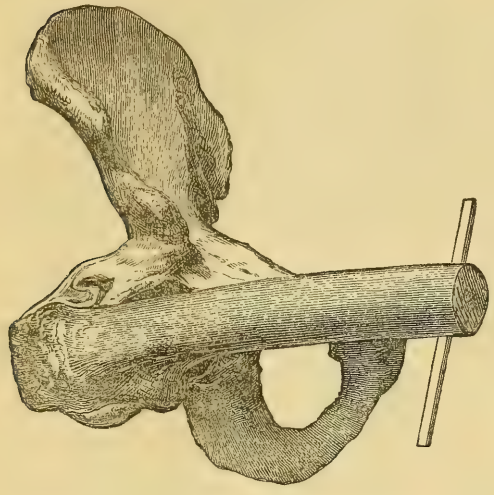


Fig. 231. Relaxation of Y ligament by flexion. (Bigelow.)

method may now prove successful." Bigelow (op. cit., p. 48) says, "Flex the thigh, and abduct, or circumduct it outwards, at the same time rotating it outwards." "Lift up, bend out, roll out."] In describing the former [traction] we shall follow the rules laid down by Sir A. Cooper. In the dislocation upon the dorsum ilii, attempts may first be made to reduce the bone by placing the foot in the perineum of the side affected, and using it as a counter-extending force, while with the hands the thigh is grasped just above the knee; or, what is better, let a jack-towel be fixed to it by means of the clove-hitch, while the other end of the towel is carried round the shoulders of the surgeon; the latter should then incline backwards at the same time that his foot is making increasing pressure in the perineum; this, with slight rotation of the limb, has proved successful in several dislocations reported by the late Mr. Morgan and Mr. Cock, in Guy's Hospital Reports.[1] Should these efforts not prove successful, a sheet must be passed between the dislocated thigh and the perineum, and its ends fastened to a staple firmly fixed to the floor or wall behind the patient, and somewhat below him, so as to be in a line with the axis of the displaced limb; or a strong well-padded leather girth, with an opening in it sufficiently large to admit the injured extremity, and to press on the perineum on one side and the crest of the ilium on the other, may be substituted for the sheet. The trunk being thus securely fixed, a padded leather belt, with straps and rings attached, is to be tightly buckled to the thigh above the knee, or a jack-towel may be fastened to the limb, previously protected by a wet bandage, by means of the clove-hitch. The knee being now slightly bent and brought across the opposite thigh, a little above the knee, one end of a multiplying pulley should be fixed to the rings of the leather belt or towel, and the other end to a staple fixed in the wall in front of the patient. The extending and counter-extending forces being thus adjusted in the axis of the displaced limb, traction should be slowly made with the pulley till the head of the bone has approached the acetabulum, when on the surgeon gently rotating the limb inwards, the bone usually slips into its place. If difficulty occur in raising the bone over the acetabulum, a towel is to be placed under the thigh, as near the joint as possible, so that the bone may thus be lifted over the edge of the socket. When this is accomplished, the movements of the joint will be

Fig. 232.

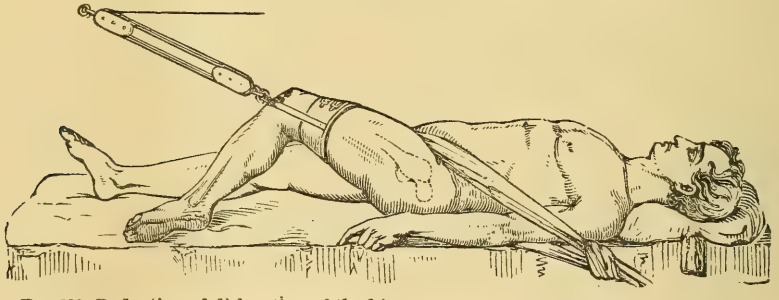


Fig. 232. Reduction of dislocation of the hip on the dorsum ilii. (After Sir A. Cooper.)

[1] Vol. I., p. 79.

found to be perfectly restored: and this is the best, and indeed the only test of reduction which is necessary.

The reduction of the dislocation into the ischiatic notch may be effected in nearly the same way as the dislocation on the dorsum ilii, the chief points of difference being, that the patient should be placed on his sound side instead of on his back; that the direction of the extension should be across the middle of the sound thigh instead of immediately above the knee; and lastly, that the head of the bone should be assisted over the edge of the acetabulum, by means of a round towel placed under the upper part of the thigh and over the shoulders of an assistant, who, at the same time resting both his hands on the patient's pelvis, gradually raises his body, and so lifts the bone into its socket. Notwithstanding that the reduction of this dislocation is pronounced by Sir A. Cooper to be in general extremely difficult, the cases which he has given in illustration scarcely bear out his assertion. This is one of the forms of dislocation of the hip in which the flexion method of reduction has been practised with great success, after the ordinary means had failed. [Bigelow (op. citat., p. 67) says: "The reduction is simple. The head of the bone having reached its present position by circumduction of the flexed limb inward, must be reduced by circumduction of the extended limb inward. When the thigh is raised perpendicularly to the floor, the head of the bone is unlocked and lies below the socket, and needs only to be jerked upward into its place; or the suspended pelvis may be depressed, or the thigh abducted and rotated outward, as in the common dorsal dislocation." "It will be observed that by the flexion method this luxation, and that upon the dorsum, are reduced in the same way, and with equal facility."] Thus Mr. Wormald succeeded six weeks after the accident, and when pulleys had been in vain.[1]

Fig. 233.

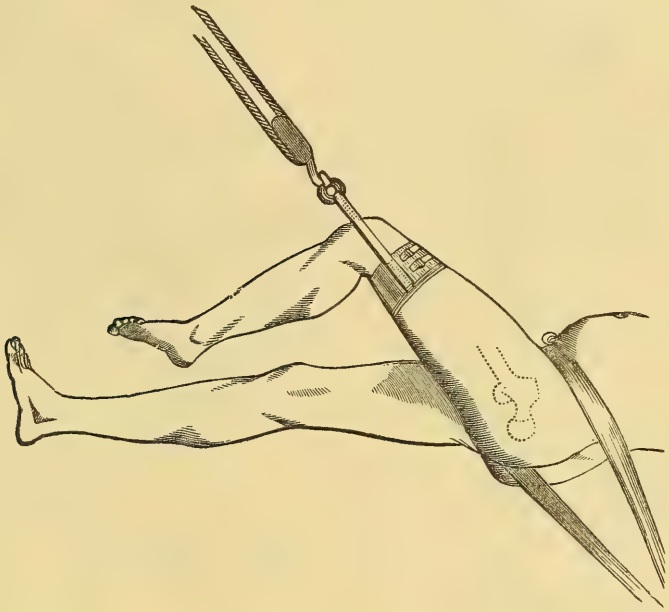


Fig. 233. Reduction of dislocation of the hip into the sciatic notch. (After Sir A. Cooper.)

3. *Dislocation downwards and inwards, or into the obturator foramen.*—In the dislocation downwards, the head of the femur is thrown into the obturator foramen, and lies upon the obturator externus muscle; the pectineus and adductor brevis have been found torn, and the psoas and iliacus muscles, together with the glutei and the pyriformis, put on the stretch or partially lacerated.

Symptoms.—The limb is lengthened to the extent of about two inches; it is abducted and advanced in front of the other; the foot is pointed forwards, and neither inwards nor outwards. ["The limb is unequivocally flexed and abducted, the heel being raised from the floor and the

[1] Medical Times and Gazette, Aug. 16, 1856.

toe pointing outward and forward."—Bigelow (op. cit., p. 71).] The trochanter major is less prominent than natural; and

Fig. 234.

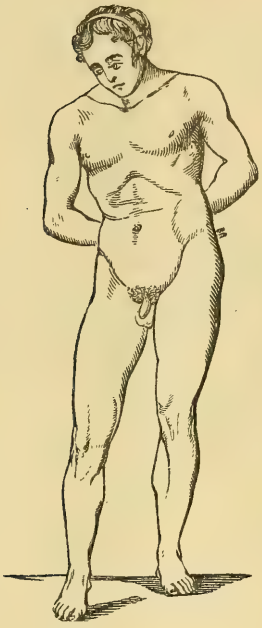


Fig. 234. Dislocation of the hip into the obturator foramen. (After Sir A. Cooper.)

there is a slight concavity at the upper and front part of the thigh, behind which the head of the bone can be felt on making deep pressure; the body is bent forwards and somewhat to the injured side by the psoas muscle. The limb cannot be adducted or extended without some force, and this movement causes pain and numbness.

Causes.—Any accident by which the thighs become suddenly and violently separated from each other, is sufficient to produce this dislocation; hence it has happened from heavy weights, as a mass of earth, falling on the back and forcing the limbs apart. Pirrie saw it caused by a person jumping out of bed in great haste, whose right foot was entangled by the blankets in bed while the left foot reached the floor.[1] It has also been known to occur from the sudden movement of a carriage which a person was in the act of mounting, having one foot on the ground, and the other on the step of the vehicle.

[1] Pirrie, Principles and Practice of Surgery, p. 320.

Treatment.—The reduction of this dislocation may be accomplished in the following manner: If the dislocation be recent, the patient should be laid on his back, and the pelvis fixed by a girth, which is made completely to surround both ilia, while its ends are fixed to a staple placed on the opposite side to the injured limb. Another girth is to be placed between the pudendum and the upper part of the luxated thigh, and its ends carried underneath the other, so that the two shall interlock. A pulley being now attached to these ends, extension must be slowly made, in a direction obliquely upwards and outwards, until the head of the bone begins to move from its abnormal position. The surgeon must then grasp the ankle of the dislocated limb and draw it towards and behind its fellow, when the bone usually slips into its place. Care must be taken not to raise the limb too much while adducting it, or the head of the bone may be thrown into the ischiatic notch. ["Flex the limb towards a perpendicular, and abduct it a little to disengage the head of the bone; then rotate the thigh strongly inward, adducting it, and carrying the knee to the floor." "As in reducing the pubic dislocation, the last half of

Fig. 235.

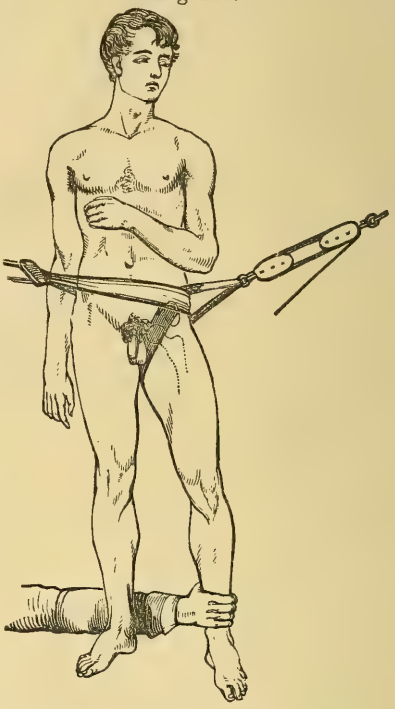


Fig. 235. Reduction of dislocation of the hip into the obturator foramen. (After Sir A. Cooper.)

this manœuvre is an inward circumduction of the flexed limb, accompanied with rotation, and is practically the reverse of the

Fig. 236.

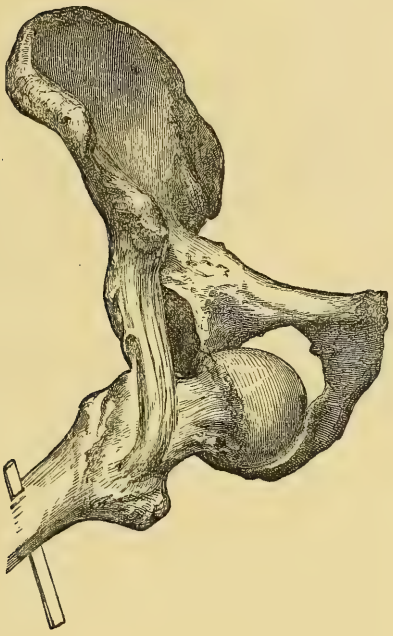


Fig. 236. Dislocation into obturator foramen. (Bigelow.)

flexion, abduction, and eversion by which a dorsal dislocation is reduced from the

Fig. 237.

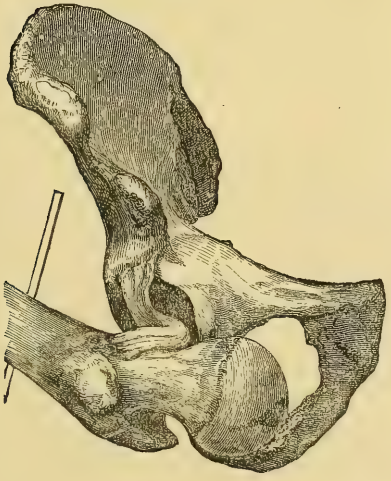


Fig. 237. Reduction of the same. (Bigelow.)

opposite side of the socket. In this manœuvre the action of the ligament may be aided, if necessary, by a towel passed round the head of the femur to draw it upward and outward. Rotation outward may be substituted for inward rotation."—Bigelow (Op. cit., p. 80).]

4. *Dislocation upwards and inwards, or on the pubes.*—Notwithstanding this dislocation is usually designated as the dislocation on the pubes, the head of the femur does not rest so much on that bone as on the ilium; hence the term ilio-pubic, which is applied to it by Malgaigne, is the more correct designation. In an old dislocation of this nature, dissected by Sir. A. Cooper and figured in his work, the head and neck of the bone occupied a position beneath the psoas and iliacus muscles, and the anterior

Fig. 238.

Fig. 238. Dislocation of the hip on the pubes. (After Sir A. Cooper.)

crural nerve, and external to the femoral artery and vein. Upon the pubes (qy. ilium?) a new acetabulum was formed for the neck of the thigh-bone, the head of the bone being above the level of the pubes.

Symptoms.—The limb is everted, abducted, and shortened to the extent of an inch; it cannot be rotated inwards, but can be slightly flexed in a direction outwards. The head of the bone can be felt in the groin, generally to the outer side of the femoral artery, and sometimes it forms a very distinct projection; the great tro-

chanter lies nearer to the mesial line and to the anterior superior spine of the ilium than natural, and the roundness of the hip is consequently lost. This accident can be readily distinguished from a fracture of the neck of the femur by the greater immobility of the limb, but, above all, by the

Fig. 239.

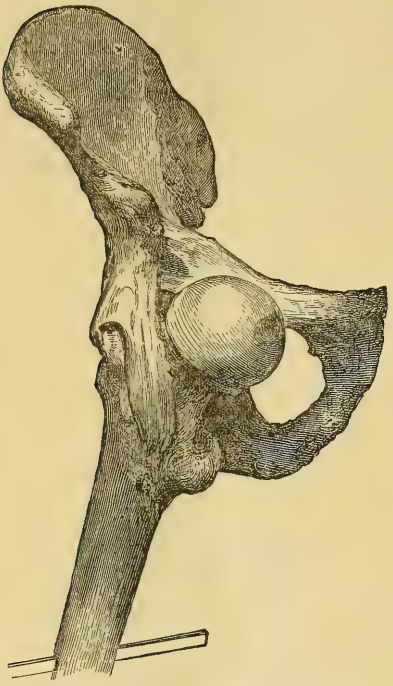


Fig. 239. Ilio-pubic dislocation. (Bigelow.)

situation of the head of the bone in the groin.

Causes.—A sudden forcing of the body backwards while the thighs are fully extended, or a sudden and forcible extension of the thighs while the body is fixed, or a sudden and simultaneous extension of both body and thighs. More rarely this dislocation has been caused by sudden abduction of the limb, combined with rotation outwards. The dislocation has been brought about by a person unexpectedly putting his foot into a hollow in the ground, when, to prevent falling forwards, he throws his body backwards, and the head of the femur is thus tilted out of its cavity upon the pubes or ilium.

Treatment.—The patient is to be placed on his uninjured side, counter-extension to be made upwards and forwards in front of his body, and extension downwards and backwards behind the axis of the body. After this has been continued for some time a towel is to be placed under the upper part of the thigh, so as to lift the head of the bone over the edge of the acetabulum. ["Briefly, while drawing upon the thigh, flex, and abduct it to disengage the head; then rotate inward, and when the head of the bone leaves the pubes, continue the rotation while straightening the limb; or circumduct the bent limb inward. Aid these manœuvres by drawing the flexed groin outward with a towel, or otherwise pressing it."—(Bigelow, op. cit., p. 92.) See also an interesting case reported by Dr. Erskine Mason (N. Y. Med. Rec., April 8, 1876, p. 234). After failing in several attempts, counter-extension was made by a towel passing over the perineum, and then the leg and thigh being extended for a few moments, it was pressed "a little backwards behind the other, and the head of the bone glided into the acetabulum." In this case the abduction was very slight, and it was with difficulty that it could be produced; the limbs were parallel, and the shortening was but a quarter of an inch.]

Unusual varieties of dislocation.—Upwards.—There are two forms of displacement upwards—in one, the head of the bone occupies the notch between the anterior superior and the anterior inferior spine of the ilium; in the other, it is situated between the margin of the acetabulum and the anterior inferior spine, or a little to the inner or outer side of this process. The symptoms are, a shortening of the limb from two to three inches, abduction and strong rotation outwards, flattening of the hip, and fulness, or a distinct tumor in the situation of the head of the bone, which moves in unison with the limb. Reduction may be accomplished by extension and counter-extension, combined with adduction and rotation inwards of the limb.[1]

Downwards.—One of the most unequivocal examples of this accident occurred in the practice of Mr. Luke, at the London Hospital.

The limb was lengthened one inch, without either inversion or eversion. The head of the bone was distinctly felt, and thought to be in the lesser ischiatic notch. The reduction was effected by manipulation. The man dying shortly after, from the effects of broken ribs, the dislocation was easily reproduced, when the head of the bone was found immediately below the acetabulum, and midway between the ischiatic notch and the thyroid foramen. The capsular ligament was lacerated below, and the gemellus inferior and the quadratus femoris were torn through.[2]

Backwards and downwards.—In this dislocation, the situation of the head of the bone varies slightly, both as to the back-

[1] See Malgaigne, tome ii., p. 869 et seq. Guy's Hospital Reports, vol. i., pp. 79 and 97.

[2] Medical Times and Gazette, June 2, 1858.

ward and downward extent of its displacement. Most frequently it is lodged in the depression which exists between the tuberosity and the spine of the ischium.

Fig. 240.

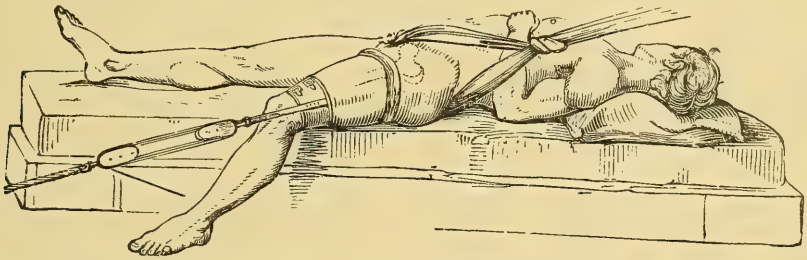


Fig. 240. Reduction of dislocation of the hip on the pubes. (After Sir A. Cooper.)

In eight out of ten cases Malgaigne[1] found the head of the bone on a level with the spine of the ischium, while in the remaining two, it was a little below, and it may be dislocated still further backwards and downwards, into the lesser ischiatic notch. In Mr. Adams's case, exhibited at the meeting of the Pathological Society (October 19, 1869), the head of the bone rested on the body of the ischium between its spine and the acetabulum. In this case, the capsule was lacerated at its posterior part, and the obturator externus and the quadratus femoris muscles were torn through.[2] The symptoms of this dislocation closely resemble those of the dislocation into the ischiatic notch: the limb is flexed, adducted, and rotated inwards and slightly elongated, and the head of the bone projects backwards, though, in some cases, it could with difficulty be felt. Reduction is to be effected by extension made in the direction of the axis of the deformed limb, combined with rotation of the thigh outwards, and pressure on the head of the displaced bone.

Forwards into the perineum.—This dislocation is produced by a heavy weight falling on the back, while the body is bent forwards, and the legs are apart. The symptoms are well marked: the leg and thigh are at a right angle with the body, the toes slightly turned inwards or outwards, the natural form of the nates is lost, and the head of the femur forms a tumor, in the perineum, which moves with the limb. Reduction is effected by extension in the axis of the displaced limb, aided by manipulation.

Mechanism of dislocation of the hip.—It was long ago remarked by Sir A. Cooper, that there was something a little anomalous in the frequency of the dislocation of the femur upwards and backwards, that being the direction of all others most protected against dislocation, by the "capsular ligament being there the strongest, the edge of the acetabulum most elevated, and the ligamentum teres offering the greatest hindrance to displacement in that direction;" whereas for the dislocation into the foramen ovale, which is one of the least frequent, all the above conditions are reversed. So again, the greater prevalence of dislocation in the four usual directions, "is not to be considered as a mere matter of chance, but as the natural result of the influence of the muscles which draw the bone into these positions." He attributed therefore the occasional occurrence of the so-called anomalous dislocations, either to some mechanical obstacle, as a portion of broken bone resisting the action of the muscles, or to the latter having lost all power of contraction, as in collapse. Under these circumstances, he adds, "the head will remain where it was placed by the mere physical force which drove it from its socket."

It is obvious from the above quotations, that Sir Astley regarded the muscles as the sole agents in drawing the head of the bone into the situations where it is usually found, but he nowhere associates their action with the position of the limb which caused the dislocation; and without taking this into consideration, it would be impossible to account for the dislocation being so much more frequent on the dorsum of the ilium than in any other situation.

If we analyze the causes and symptoms of the four usual varieties of dislocation of the hip, it will be seen that they group themselves thus. In two, the head of the bone is thrown behind the acetabulum; in the other two, it is in front; and if we examine further, we shall see that the two backward dislocations are produced by forced flexion and adduction, combined probably with rotation inwards of the limb; the two forward dislocations, with forced extension and abduction combined with rotation outwards of the limb; in the former,

[1] Malgaigne, op. cit.
[2] Lancet, November 6, 1869, p. 640.

the capsule is lacerated at its posterior and inferior part; in the latter, at the inferior and internal; and it depends probably on the force which produced the injury whether the capsule shall be entirely separated from the femur, or only partially separated, or not separated at all, but merely lacerated to a greater or less extent. This is the principal cause which, I believe, regulates the distance to which the head of the bone shall be drawn or driven, both in the backward and forward dislocations; and it will account partly for the greater difficulty of reducing a dislocation into the sciatic notch, than one on the dorsum of the ilium; in the latter the laceration of the capsule being usually more extensive than in the former, in which there may be a mere slit.

The great frequency of the posterior dislocations as compared with the anterior, is doubtless owing to the greater prevalence of flexed positions of the body and limbs than the opposite: so that when one is overtaken by an accident the body is found more frequently in this posture than in any other. Then, as to the greater frequency of dislocations on the dorsum ilii than into the sciatic notch, it may be accounted for in the same way as a limb becomes shortened when it is fractured, *i. e.*, the muscles passing from the pelvis to the thigh missing the resistance they are ordinarily accustomed to—the integrity of the bone in the one case, and the bottom of the acetabulum in the other—contract to their utmost, and a backward dislocation should be always on the dorsum, if the force of the muscles were not counteracted by some other force, which in these cases is nearly always the untorn portion of the capsule. I cannot think with some modern writers that the position of the limb is determined solely by the capsule, and that the muscles exercise no influence; on the contrary, I believe with Sir A. Cooper, that they are the principal, though not the sole agents; and, as in fractures the displacements are occasioned partly by muscular action, and partly by the force which produced the fracture, so in these dislocations, the position of the head of the bone is determined by the joint influences of the force which caused the dislocation, the contraction of the muscles, the rebound of the limb from the abnormal position into which it had been thrown, and the extent of laceration of the capsule.

[Bigelow describes the Y ligament as the anterior part of the capsule, "which when well developed, exhibits an internal and an external fasciculus, diverging like the branches of the inverted letter Y." (See FIG. 230, p. 964.) "The Y ligament, the internal obturator muscle, and the capsule subjacent to it, are alone required to explain the usual phenomena of the regular luxations." In the regular dislocations one or both branches "are unbroken and their signs are constant." In the irregular dislocations both branches "are broken, and they offer no constant signs." In the regular dislocations "the muscles are not essential to give position to the limb *nor desirable as aids in its reduction.*" (The italics are ours.) "The Y ligament will alone effect reduction, and explain its phenomena, a part of those connected with the dorsal dislocations excepted." (Op. cit., p. 4.) Dr. Wm. Warren Greene (Bost. Med. and Surg. Journ., March 3, 1870, p. 153), says, "the main opposing force to the reduction of dislocations is the untorn portion of the capsular ligament." The primary object of all efforts at reduction should be "the relaxation of the untorn portion of this ligament."]

Let us now direct attention to the two forward dislocations. The position of the limb which gives rise to these displacements we have seen to be, one of forced extension, abduction, and rotation outwards: the capsule is strained at its weakest part, and gives way inferiorly and internally. The abductor muscles which are put on the stretch by the position of the thigh which produces the backward dislocations, are here relaxed, and the adductors stretched; and it depends probably on the degree of extension into which the limb has been forced by the accident whether the head of the bone shall be lodged in the obturator foramen or on the pubes. In simple abduction with slight extension, which produces the obturator dislocation, the anterior part of the two small glutei, with the tensor vaginæ femoris, will be relaxed, and the pectineus and adductors will be put on the stretch, and draw the bone directly into the thyroid foramen; but should there be hyperextension of the thigh in addition to abduction, the three first-named muscles will be stretched, and combining with the adductors the head of the bone will be drawn upwards on to the pubes or ilium.

It has been recently asserted that "there is but one primary dislocation of the femur at the hip joint, namely, that in the foramen ovale, or downwards and inwards;" according to which doctrine about nine-tenths of all the dislocations of the hip are secondary—a statement sufficiently refuted not only by the way in which these dislocations are brought about, but by the specimens referred to by the writer to establish his case.[1] On the contrary, secondary dislocations are rare, and unless produced by the surgeon in his attempts at reduction, can only be conjectured to have happened on the evidence of the patient.

[1] See British Medical Journal, June 11, 1868.

The limits of this article will not permit me to go into the philosophy of the so-called anomalous dislocations; but the above observations seemed necessary in order to understand the principles that should guide us in our attempts to reduce these dislocations by manipulation.

Reduction by manipulation.—The method of reducing a dislocated limb by manipulation has been practised from the earliest times, but, having fallen into desuetude, has been revived of late years, and now seems likely to supersede the traction method by pulleys. [We have preferred to direct the reader's attention to this subject in connection with the different dislocations.] The object of the movement is, of course, to bring the head of the displaced bone close to the opening in the capsule, and the best means of doing this is to make it traverse the route by which it escaped. "The reduction of a dislocation is most easy when the dislocated bone follows the same course, but in the opposite direction, to the one along which it originally passed; and the most favorably position of the limb for reduction, is that in which the displacement occurred."[1]

Bearing in mind this principle, and having regard to the manner in which the dislocation occurred, it should follow that the proper manipulations for the reduction of the backward luxations, must be flexion and adduction of the limb; and for the forward, abduction and hyperextension. The first movement brings the head of the bone close to the acetabulum, the second raises it from its edge, when a slight rotation, outwards in the two backward dislocations, and inwards in the two forward, rolls the bone into the socket. The method of reduction may be formulated as follows:

1. *Dislocations backwards*, iliac or ischiatic. Flex the thigh to rather more than a right angle, adduct till the knee reaches somewhat over the opposite side of the body, and then rotate outwards, and bring downwards.

2. *Dislocations forwards*, supra or infrapubic. Abduct the thigh, rotate it somewhat outwards, and carry it into hyperextension, then rapidly rotate inwards, and place it straight.

Although most recent dislocations of the femur may be reduced with comparative ease, by one or other of the methods described in this article, cases every now and then occur in which the greatest difficulty is experienced. Excluding from consideration maladroit efforts and muscular resistance, the difficulty seems to arise from some of the following causes. 1. A portion of the torn capsule may get in the way, as was well seen in Adams's case before cited. 2. The strong untorn portion of the capsule may offer resistance. 3. The rent in the capsule may be so small as not to admit of the return of the bone. ["If the capsular orifice is too small to allow reduction, it should be enlarged," and this may be done "at will and with impunity, by circumduction of the flexed thigh." (Bigelow, op. cit., p. 5.)] 4. A portion of the margin of the acetabulum may be broken, and so allow the capsular ligament to yield before the head of the bone.

In illustration of the two last impediments, the reader is referred to Dr. Fenner's case of dislocation on the dorsum ilii; in which that gentleman divided all the muscles passing from the pelvis to the thigh, and found it still impossible to reduce the dislocation, till the rent in the capsule through which the head of the bone had escaped was enlarged from one-half to three-quarters of an inch.[1]

Mr. Hamilton also exhibited, on November 28, 1868, to the Dublin Pathological Society, the preparation of a dislocation into the sciatic notch, which had taken place three weeks previously, and which it had been found impossible to reduce, after repeated attempts. The causes of failure were the smallness of the rent in the capsule, and a fracture of the lower edge of the acetabulum, so that the capsular ligament yielded before the head of the bone.[2] The success which sometimes attends later attempts to reduce these dislocations is probably owing to the tearing through or detachment from the femur or the acetabulum of those portions of the capsule which formed the impediment in the previous efforts.

A question which the surgeon will sometimes be called on to decide is, how long after a dislocation of the hip may its reduction be attempted? and on this point authorities differ; much must necessarily depend on the age and constitution of the patient, and something on his own wish in the matter. Fabricius Hildanus mentions the case of a lady of rank, in whom reduction was attempted fifteen weeks after the accident, but without success: it has, however been accomplished after the lapse of six months,[3] twelve months,[4] and even longer, as in the remarkable case of Mr. Cornish, related by Sir A. Cooper. Under ordinary circumstances, a reduction of the hip is hardly to be looked for later than eight weeks after the accident, which was the limit placed by the distinguished surgeon just named, beyond which it should not be attempted. Fergusson has never witnessed a successful effort beyond the

[1] See Arch. f. klin. Chir., vol. iv., p. 1. Professor W. Busch, New Sydenham Society's Year-Book, 1863.

[1] Hamilton, op. cit., p. 338.

[2] New Sydenham Society's Biennial Retrospect for 1867–8, p. 233.

[3] Gockelius, Gallicinium Medico-practicum, Ulm, 1700, p. 228.

[4] Malgaigne, tome ii., p. 821. Cooper, Case 64.

period of three weeks; but he would deem it quite correct to make trial of all reasonable means at a much longer date, though he could not be at all sanguine of success after two or three months. [Professor G. E. Post (N. Y. Med. Rec., May 11, 1878, p. 366) reports a case where a dislocation of the right thigh was successfully reduced by manipulation at the expiration of six months. Doutrelepont (Berlin Klin. Wochenschrift, July 31, 1876, N. Y. Med. Record, October 14, 1876, p. 670) reports a case of successful reduction after three months and a half, by manipulation preceded for a few days by permanent extension and counter-extension. The age of the latter patient was seven, and of Dr. Post's thirteen. Bigelow says of old luxations, "the period, during which reduction is possible, is determined by the extent of the obliteration of the socket, the strength of the neck of the femur, and the absence of osseous excrescence." It may be necessary in these cases to use pulleys, and then right-angled extension by a special apparatus is much more effective than the usual method. (Op. cit., p. 6.)]

Fig. 241.

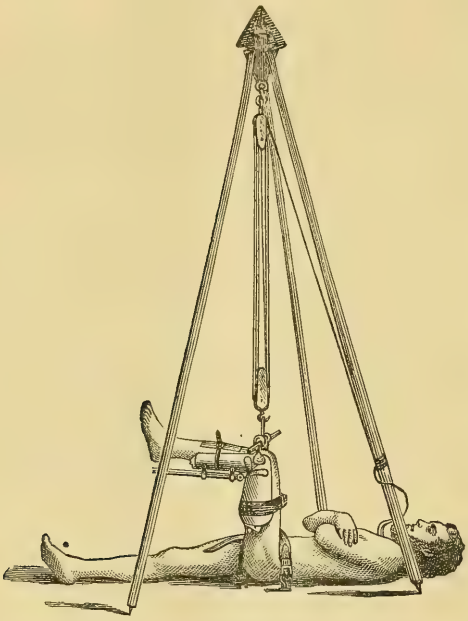


Fig. 241. Apparatus for right-angled extension (Bigelow).

Before making these attempts it would be well that the surgeon should bear in mind that fractures of the neck of the femur, suppuration in and around the joint, and other injuries which have led to a fatal result, have followed too prolonged and violent efforts to reduce the bone.

Equally important with the determination of the longest period at which reduction of this dislocation may be attempted, is the line of practice to be pursued when the injury is complicated with a fracture of the femur of the same side. Guy de Chauliac laid down the following general rule. When a dislocation is complicated with a fracture, let the dislocation be first reduced, and then the fracture, if that is possible; but if it is not possible, let the fracture be first reduced, and after the callus is firm, the dislocation.[1] Boyer considered that a dislocation of an orbicular joint could not be reduced if a fracture were present, and that when the latter had united, the reduction of the dislocation could not be effected, owing to its age. However, Sir A. Cooper relates a case (29th) in which reduction was effected five weeks after the double accident, the fractured bone having become sufficiently firm in this time to admit of extension being made; but this occurred in a youth sixteen or eighteen years of age, and it is doubtful whether the same success would have been attained had the patient been older. The rule would seem to be this: whenever there is room enough above the fracture to fix securely an extending apparatus, reduction of the dislocation should be first attempted, and afterwards the fracture. [Hamilton has no confidence in extension, but believes that reduction is sometimes possible by pressure if the surgeon will act promptly. If attempts at reduction are postponed until the femur has united, they will probably be futile. (Fractures and Dislocations, 5th ed., p. 735.)] Several cases are now upon record in which this practice has been successfully carried out: thus, Bloxam reduced a dislocation upon the pubes on the eighth day after the accident;[2] and M. Etène one into the ischiatic notch, the fracture being in the centre of the bone.[3] In every attempt of this nature, the limb should be first firmly encased in splints, and preference given to the plan of reduction by manipulation.

Dislocations of the Patella

Are not of very frequent occurrence, but they may take place in the following directions, viz., outwards, inwards, upwards, and edgeways; they may be complete or only partial, and are more frequently produced by muscular action than any other dislocation, if we except the lower jaw. [Dislo-

[1] Malgaigne, tome ii., p. 203.
[2] Gazette médicale, 1833, p. 660.
[3] Ibid., 1838, p. 751.

cation of this bone is occasionally met with as a congenital defect. The writer reported in the Am. Jour. Med. Sciences, July, 1865, p. 82, a case of dislocation of both patellæ, which was hereditary, running through three generations.]

Outwards.—This is by far the most common variety of the accident, and may be occasioned either by muscular action or by direct violence; thus, it has been known to take place from a sudden jump on one side to avoid being run over; from wrestling; but more frequently from falling down and striking the inner side of the knee. It is said to occur generally to those who have a slight inclination of the knee inwards; but Malgaigne found only one patient so affected out of forty-six cases of this luxation.

The situation of the patella varies. When only partially dislocated, its inner half rests on the articular surface of the outer condyle, and owing to the obliquity of that surface, its outer margin becomes tilted forwards, forming a ridge in front of the condyle. In complete dislocations, the articular surface of the patella rests on the outer side of the condyle, with its inner margin directed forwards; the breadth of the knee is increased, the limb is slightly flexed and fixed, and any attempt to move it from this position causes great pain.

The dislocation *inwards* is very rare, and seldom complete, and happens usually from falls on a projecting body, by which the patella is struck on its outer edge, and so driven inwards. The symptoms resemble those of the dislocation outwards, but the projection of the patella is of course in front of the inner instead of the outer condyle.

From experiments made by Professor Streubel[1] on the dead subject, it would appear that even incomplete dislocations of the patella outwards cannot take place without laceration of the capsule of the joint; and in complete dislocations, this laceration is often very considerable. The difficulty which is sometimes experienced in reducing this dislocation, after the extensor muscles have been relaxed to the utmost, is owing to the tension of the ligaments being too great to allow of the ridge on the inner surface of the patella being raised above the process on the outer condyle. The professor was not able to produce a dislocation inwards, and he believes that it can only occur in those whose ligaments have been previously relaxed.

Treatment.—This consists in placing the patient in a sitting posture, raising the limb towards the trunk, and then pressing down that edge of the patella which is most remote from the joint; this raises the opposite edge, and it is immediately drawn by the action of the muscles into its natural situation. In a patient who was lately under my care with this dislocation, the knee was reduced with great ease by straightening the leg, and making slight lateral pressure.

In the dislocation *edgeways* the patella is turned on its axis, so as to bring its lateral margins forwards and backwards, and its surfaces sideways; indeed, in some instances this has taken place to such an extent as almost to reverse the normal position of the two surfaces. According to Malgaigne, it is the outer edge of the bone which is most frequently directed backwards, being buried in the fossa between the condyles. [The writer finds ten cases reported, in the last ten years, in the periodicals mentioned below. In five of these the anterior surface presented outwards and in five inwards. They are to be found as follows: Bost. Med. and Surg. Journ., Oct. 25, 1877, p. 487. N. Y. Med. Rec., May 15, 1869, p. 123; June 15, 1869, p. 176; April 1, 1873, p. 164; Dec. 1, 1874, p. 627; Dec. 30, 1876, p. 840; Jan. 20, 1877, p. 46; Jan. 27, 1877, p. 61; May 26, 1877, p. 336; Oct. 25, 1879, p. 389.] There is no difficulty in detecting the nature of these dislocations; the patella can be easily felt in its unnatural position, causing a projection in front of the joint, and a depression on each side, while the joint is immovably fixed in an extended position. This, like the other forms of dislocation of the patella, has been known to occur from muscular action, as in jumping; but most frequently it has resulted from a sudden blow applied to the patella while the knee was bent, as in Mr. Mayo's case, related by Sir A. Cooper, of the life-guardsman, in whom the injury was caused by the knee of another soldier, as the opposite lines rode through each other. [The case reported in the Med. Record, June 15, 1869, by Assist. Surg. Sternberg, U. S. Army, was caused by a similar accident; here the bone was tilted upon its outer edge, the anterior surface looking outwards.]

In a case related to me by Mr. Flower, the patient, a young man aged twenty-two, was stepping over the seats of the gallery of a theatre, and fell between them, without, so far as he was aware, striking the knee; severe pain and inability to flex the joint were the immediate results. On examination Mr. Flower found the patella twisted on its longitudinal axis, with its outer edge projecting forwards under the skin, and its inner edge wedged in between the condyles of the femur and the head of the tibia. The limb was extended, and all attempts at reduction by bending the knee, manipulating the patella, etc., produced great pain, and were unavailing till chloroform was given, when, on bending the knee, the bone directly slipped back into its place.

[1] Schmidt's Jahrb., 1866, vol. cxxxix., p. 311.

Treatment.—In the cases just alluded to, reduction was effected by suddenly bending the knee. In other cases the same result has been obtained by pressing the edges of the bone in opposite directions while the leg was extended; and in others, both these means and even the more violent ones of dividing the quadriceps muscle and the ligamentum patellæ, opening the joint, and endeavoring to raise the bone from its position by an elevator, have all failed. The extreme difficulty that has been experienced in the reduction of some of these dislocations is supposed to arise from the upper extremity of the bone having become firmly wedged in the intercondyloid notch. [Complete anæsthesia is the most valuable aid to the reduction of these dislocations, for here there can be no question as to the muscular resistance to be overcome. With this aid most of the cases reported above were reduced with ease.]

The dislocation of the patella *upwards* is an exceedingly rare accident, and cannot take place without a rupture of the ligamentum patellæ; this is most usually brought about by a sudden and violent contraction of the quadriceps muscle, made in an effort to prevent falling backwards; the dislocation has also taken place from division of the ligament by sword-cuts, and by falling with the knee on broken glass. The nature of the accident is at once obvious, from the position of the patella, the hollow beneath it, and the inability of the patient to bear the weight of his body on the limb. It is usually followed by a good deal of inflammation of the joint, which should be first subdued, and the dislocation then be treated in all respects as a fracture of the patella.

Dislocations of the Knee-joint.

The tibia may be displaced laterally, or forwards and backwards; each of these dislocations may vary in degree; but the former are always partial, and the latter generally complete; they are usually combined with a slight rotation of the tibia on its axis.

Lateral dislocations.—In these the head of the tibia is partially displaced from the condyles of the femur in a lateral direction. In the dislocation outwards the inner articular surface of the head of the tibia is driven on to or towards the external condyle of the femur, causing much deformity, from the leg and thigh being no longer in the same axis. [A case is reported in the Phil. Med. Times, Aug. 5, 1876, p. 536, of dislocation of the left knee outwards, with an inward rotation of the tibia, so that the crest of the tibia and the top of the foot faced toward the right.] In the dislocation inwards, the outer articular surface of the head of the tibia is displaced towards the internal condyle, producing an analogous deformity.

The *causes* of these dislocations are falls on the feet, sudden twists of the knee-joint, or blows directed laterally against the lower end of the femur. The deformity which accompanies them is so characteristic of their nature, that a mistaken diagnosis is not likely to occur. They are easily reduced by moderate extension, combined with rotation, or by pressing the displaced tibia into its natural position. There is, however, one accident which very closely resembles them: a separation of the lower epiphysis of the femur, or a fracture partly through it. A little boy, four years of age, was riding behind a cab, when his left leg got between the spokes of the wheel, and he was brought into the Westminster Hospital with an apparent dislocation of the tibia inwards. With very slight extension of the limb, the deformity was removed and distinct crepitus elicited; the existence of this sign, then, is conclusive as to the nature of the injury.

Dislocations in the antero-posterior direction cannot take place without the application of great force. The dislocation of the tibia forwards is most frequently brought about by a forced extension of the knee-joint, or by a heavy body striking the lower and front part of the thigh while the limb is extended. [A partial dislocation forwards produced by a bucket of sand falling eight feet, and striking the patient on the head, is reported in the article last mentioned by the writer.] The dislocation backwards is usually the result of direct violence applied to the upper and front part of the tibia when the knee is bent. In both of these displacements considerable injury is done to the soft structures of the joint, and the muscles in the neighborhood are sometimes torn through. In the dislocation forwards the popliteal artery is also more or less compressed, and this has led to subsequent gangrene of the limb. [In the St. Barth. Hosp. Rep., vol. v. (Am. Journ. Med. Sciences, Jan. 1870, p. 193), Mr. Lowe reports two cases of dislocation forwards, accompanied by rupture of the popliteal artery, rendering amputation necessary.] The symptoms of the dislocation forwards are a swelling in the ham, produced by the condyles of the femur, and another on the front and lower part of the thigh, caused by the head of the tibia, while a depression exists below the former bone and above the latter. The limb is shortened to a variable extent, according as the tibia is higher or lower in front of the femur. In the majority of cases the limb is extended, but in some it has been flexed; the mobility also varies from almost complete fixity to a considerable amount of motion in every direc-

tion. In the dislocation backwards, the head of the tibia forms a projection in the ham, and a deep depression exists in front of the knee, below the projecting condyles of the femur. Thus there are the same projections and depressions as in the last described accident; but their position is reversed. The limb is extended and shortened, and the patella is placed horizontally, with its anterior surface looking downwards and its upper margin forwards. This dislocation is more rare than the preceding one.

Treatment.—The reduction of these dislocations is not difficult; extension must be made from the ankle, in the axis of the displaced tibia, and counter-extension from the thigh, aided, if necessary, by pressing the condyles of the femur upwards, and the head of the tibia downwards. After reduction is accomplished, the joint must be kept perfectly motionless for two or three weeks, and the ordinary remedies employed for preventing or subduing inflammation.

Subluxations of the semilunar cartilages. Inflammation of the knee-joint is liable to be followed by enlargement of the semilunar cartilages, and by elongation of the ligaments which connect them with the tibia. Under these circumstances, a trivial accident, such as striking the toe against some projecting object while the foot is slightly everted, as in walking; or even turning suddenly in bed, should the clothes happen to catch the point of the foot, may cause a displacement of the cartilages, and bring the condyles of the femur into direct contact with the head of the tibia. The symptoms which this gives rise to are a sudden and severe pain in the joint, with inability to straighten it, followed in a short time by the effusion of fluid, and the usual symptoms of synovitis.

Bassius recorded a case of this description in 1731. It happened in a female, who had previously been the subject of severe inflammation of the joint, which ended in enlargement of the external semilunar cartilage. One day, on attempting to put the limb to the ground, she fell down; and Bassius, who was called in, found the cartilage greatly enlarged, and projecting outwards; it was reduced by pressure, but required a plaster and bandage to retain it in its place.[1] Somewhat similar cases, attended with a marked projection of the internal semilunar cartilage, have been recorded by Malgaigne and by Dequevauviller;[2] Hey[3] and Sir A. Cooper,[4] on the contrary, observed no projection or other deformity; so that the symptoms may have been due to the existence of loose cartilages in the joint. M. Gimelle[1] has related a case in which this mistake was made; but the true cause having been at length discovered, Larrey cut into the joint and removed the foreign body.

Reduction is generally easily accomplished by flexing the knee to its utmost extent, and then suddenly straightening it, imparting to the leg at the same time a slight rotatory movement. Should these manipulations succeed, the patient will be able to extend his limb and move it freely; but the plan is not invariably successful, and it then becomes necessary—all other means of reduction failing—for the patient to wear constantly a bandage or knee-cap firmly around the joint. Even when reduction is effected, similar support of the joint is required, in order to prevent a return of the accident, to which persons who have once suffered are particularly prone. In all cases some degree of inflammation of the joint is set up, which requires the usual treatment for synovitis.

Compound dislocations.—These injuries are among the most serious to which the limbs are liable, for, to the danger incidental to every wound of a large and healthy joint, there is superadded that arising from the forcible separation and displacement of the bones which compose it, and the extensive laceration of the soft structures of and around the joint, including sometimes the popliteal artery. For these reasons it is seldom possible to save the limb, and rarely advisable to make the attempt; nevertheless, if the subject of the accident be young and of good constitution, if the wound in the integuments be small, and the soft parts around the joints not much bruised or the popliteal artery injured, an attempt may reasonably be made to preserve the limb. [The favorable results of the antiseptic method offer inducements of the strongest kind, to attempt to save limbs which hitherto would have been doomed to amputation.]

Dislocations of the head of the fibula have been occasionally met with, both from relaxation of the ligaments which connect it with the tibia, and from rupture of the same by violence.[2] Reduction is effected by flexing the leg, so as to relax the biceps, and then pushing the head of the bone into its place, after reduction, a compress or cushion must be firmly fixed behind the head of the bone, so as to retain it in position, and it should be kept on for six weeks or two months.

Dislocations of the Ankle-joint.

In these dislocations there is a separation

[1] Malgaigne, tome ii., p. 968.

[2] Rev. Méd.-chir, tome vi., p. 180; tome vii., p. 311.

[3] Hey, Observations in Surgery, pp. 327 et seq.

[4] Cooper, op. cit., p. 212.

[1] Gazette médicale, 1835, p. 221.

[2] See p. 981, for a remarkable case of this dislocation.

of the articular surface of the lower end of the tibia and of the upper surface of the astragalus, and much ingenuity has been expended in discussing whether it is the tibia which is dislocated from the astragalus, or the astragalus from the tibia. If the foot were fixed in a vice, and force applied to the leg, the tibia might be separated from its connections with the astragalus, and the injury be called with perfect truth a dislocation of the tibia. If the leg were fixed in the same way, and force applied to the foot, the astragalus might be separated from its connections with the tibia, and the injury with equal truth be called a dislocation of the astragalus or foot, but if instead of fixing either leg or foot, force were applied equally and simultaneously to both, as happens perhaps in the majority of these luxations, the separation of their articular surfaces would be mutual, and neither of the above terms would be strictly correct. It is absurd, therefore, to dispute about which is the bone dislocated; neither would it be possible to adopt the *mode* of displacement as a basis of nomenclature. In all other dislocations, the distal part of the limb is assumed to be displaced, and the proximal end to be in its place; but in the case of the ankle-joint this rule has been arbitrarily set aside, without any equivalent advantage. On the contrary, it has given rise to much confusion of terms, the same accident being differently designated according to the views of the surgeon describing it. Sir A. Cooper, and most English surgeons, speak of the tibia as the bone displaced; while Petit, Boyer, and the majority of French surgeons, refer the displacement to the astragalus, hence the dislocation inwards of the English would be the dislocation outwards of the French. Not less confusion prevails in the designation of the luxations of the calcaneo-astragaloid joint; one writer calling them dislocations of the astragalus, another dislocations of the foot, and a third using these terms synonymously, whilst the majority make no distinction between those cases in which the astragalus maintains its connection with the bones of the leg and is dislocated only from those of the tarsus, and those in which it is separated from both. In the description of these several accidents, therefore, the following terms will be employed. The separation between the astragalus and the tibia will be called a dislocation of the foot at the ankle-joint; the separation between the astragalus and the os calcis and scaphoid will be spoken of as a dislocation of the foot at the calcaneo-astragaloid joint; while the term dislocation of the astragalus will be confined to the separation of this bone both from its tibial and tarsal connections.

Dislocations of the foot at the ankle-joint may take place in the following directions, placed according to their frequency,—outwards, inwards, backwards, and forwards. In the dislocation *outwards* the fibula is broken from two to three inches above the

Fig. 242. Fig. 243.

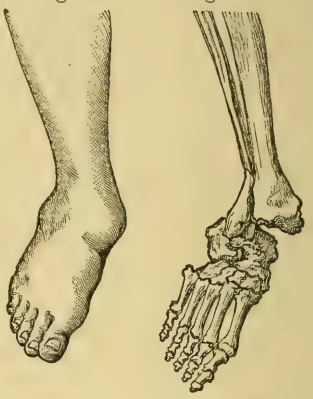


FIG. 242. The foot in Pott's fracture.
FIG. 243. The bones in Pott's fracture. (After Pott.)

malleolus; the foot is everted, and its outer edge raised, whilst its inner rests on the ground; a hollow exists at the seat of the fracture, and the extremity of the tibia projects on the inner side of the joint, immediately beneath the skin. This is the accident which goes by the name of Pott's fracture.

"The support of the body, and the due and proper use and execution of the office of the joint of the ankle," observes Pott, "depend almost entirely on the perpendicular bearing of the tibia upon the astragalus, and on its firm connection with the fibula. If either of these be perverted or prevented, so that the former bone is forced from its just and perpendicular position on the astragalus, or if it be separated by violence from its connection with the latter, the joint of the ankle will suffer a partial dislocation internally, which partial dislocation cannot happen without not only a considerable extension, or perhaps laceration of the bursal ligament of the joint, which is lax and weak, but a laceration of those strong tendinous ligaments which connect the lower end of the tibia with the astragalus and os calcis, and which constitute in great measure the ligamentous strength of the joint of the ankle. This is the case, when, by leaping or jumping, the fibula breaks in the weak part already mentioned, that is, within two or three inches of its lower extremity. When this happens, the inferior fractured end of the fibula falls inward towards the tibia, that extremity of the bone which forms the outer ankle is turned somewhat outward and upward, and the tibia having lost its proper support, and not being of itself capable of steadily preserving its true perpendicular bearing, is forced off from the astragalus inwards, by which means the weak bursal, or common ligament

of the joint, is violently stretched, if not torn, and the strong ones, which fasten the tibia to the astragalus and os calcis, are always lacerated; thus producing at the same time a perfect fracture and a partial dislocation."[1]

Besides the fracture of the fibula, which nearly always accompanies this dislocation, the internal lateral ligament is sometimes torn through, and there may be detached with it more or less of the internal malleolus; or the lower end of the tibia may be broken very obliquely, one portion of it remaining attached to the fibula, where it is connected with that bone by ligament. There is a remarkable if not a unique case, related by Boyer, in which this dislocation was unaccompanied by a fracture of the fibula, but in lieu of this, the bone was forced upwards, and its head dislocated from the articular facet of the tibia.[2]

Simple dislocation of the foot *inwards* is a rare and rather severe accident; greater force being required to produce it than the dislocation outwards; hence, in addition to the tibia being generally obliquely fractured through the malleolus, and separated from the shaft, there may also be a fracture of the astragalus, and of the outer malleolus. If there be no fracture of the latter, the external lateral ligament will be torn through; but the deltoid remains unaffected by the displacement. The symptoms of this injury are, inversion of the foot, a great prominence of the outer ankle, which almost touches the ground, and a depression on the opposite side of the ankle.

Both of these lateral dislocations are occasioned by a sudden twist of the foot outwards or inwards, as in jumping or falling from a height on the foot; and their reduction may be accomplished by extension made from the foot, the leg and thigh being previously flexed, so as to reduce to a minimum the resistance of the muscles. Two side splints, with foot-pieces made of wood, leather, or gutta-percha, or the starch-bandage strengthened with millboard, must be applied and kept on for six weeks, the patient being allowed to go about upon crutches.

Dislocation of the foot *backwards* may arise from jumping off a carriage in motion, or from a fall backwards whilst the foot is confined; from either cause, the capsular and part of the deltoid ligaments may be ruptured, the fibula broken above the malleolus, and the tibia forced from the astragalus on to the navicular and cuneiform bones. The symptoms of this accident are, a shortening of the foot and a lengthening of the heel, with a depression above the latter. The toes are pointed downwards, and the extremity of the tibia forms a projection in front of the ankle. Reduction may be accomplished in the same manner as in the last-described dislocation, and a similar apparatus is sufficient for the after-treatment.

Dislocations of the foot *forwards* is so rare that Sir A. Cooper never saw a case, and but few such are on record. One of the best-described cases is that recorded by Mr. R. W. Smith, of Dublin.[1]

The subject of the accident was a sailor, who, while assisting to raise a very heavy cask on board ship, having at the same time one leg much flexed on the foot, and the thigh on the leg, was struck by the falling of the cask just above the knee, forcing the distal end of the tibia backwards from off the astragalus on to the upper posterior surface of the calcaneum. The symptoms of this accident were, a lengthening of the dorsum of the foot to the extent of one inch, and a shortening of the leg to the extent of half an inch, the two malleoli being that much nearer the ground. The projection of the heel had disappeared, and the tibia formed a remarkable projection in front and to the inner side of the tendo-achillis. The fibula was uninjured; but the extremity of the inner malleolus had been fractured.

The only accident with which this could be confounded is a fracture of the tibia immediately above the ankle-joint; but the situation of the malleoli would be decisive as to the nature of the injury. In the few cases of this accident which have been published, reduction was not effected, and the patients remained very lame; but there seems to be no reason why cases of this description, if seen early and properly recognized, should not be reduced in a similar manner to the lateral dislocations, and treated in all respects similarly.

Compound dislocations of the foot at the ankle-joint take place in the same directions as the simple dislocations, and are accompanied by similar injury to the ligaments and bones of the joint. There is, however, superadded the wound in the integuments communicating with the joint, and there may be also laceration of the bloodvessels and tendons, and extensive comminution of all the bones of the joint, and even of the os calcis.

It would be impossible to lay down rules for the treatment of every case; each must be studied separately, and the means adapted to the circumstances present. If arteries are wounded and bleeding, they must be tied; if bones are comminuted the pieces must be removed; resection may be required in some cases, and amputation in others. As a general rule, amputation is improper, and, except under the circumstances to be presently mentioned, the

[1] Pott's Works, by James Earle, 1790, vol. i., p. 409.

[2] Boyer, Maladies chirurg., iii., p. 883.

[1] Dublin Quarterly Journal of Medical Science, May, 1852.

preservation of the limb ought always to be attempted. Our first object, therefore, should be to reduce the dislocation, by bending the leg on the thigh, and making extension and counter-extension from the foot and thigh. Reduction having been effected, and the wound cleansed from dirt and other foreign bodies, the limb must be placed on a hollow splint with a foot-piece, in such a position as admits of the easy application of dressings to the wound without disturbing the joint; then a piece of lint may be laid on the wound, and kept wet by the dropping of cold water from a bottle or other apparatus suspended above it. [Fenestrated plaster splints, thorough drainage, and antiseptic dressings offer, as we think, the most desirable treatment.] Should the case proceed favorably, little or no other treatment will be necessary, unless it be the occasional administration of opiates to allay irritation and relieve pain. Some months, however, must elapse before the patient will be able to bear upon the limb; and however complete the recovery, the movements of the joint are not always restored. [A case of this kind resulting favorably under carbolic acid dressing is reported in the Boston Med. and Surg. Jour., Sept. 25, 1879, p. 462; anchylosis of the joint ensued. See also an interesting case accompanied by fracture, reported by Surgeon Clements, U.S.A., in the Med. Rec., Oct. 11, 1879, p. 342. Although this case resulted successfully, it was only at the expense of great risk and suffering on the part of the patient, and an extraordinary amount of care and attention by the surgeon, who regarded it at last as a dangerous experiment, and would advise in a similar case resection, and the endeavor to secure anchylosis.] It was mentioned just now that, as a general rule, amputation should not be had recourse to in these accidents; nevertheless, there are circumstances which justify, and even demand, this operation. Thus, primary amputation may be advisable on account of the advanced age of the patient, or the extensive laceration and contusion of the soft parts, especially if complicated with wounds of the bloodvessels or with extensive shattering of the bones. Amputation may likewise be necessary some time after the accident, when the attempt to save the limb has failed, through diffuse inflammation or sloughing of the soft parts of the foot and leg, or consecutive hemorrhage, or on account of severe constitutional disturbance threatening the life of the patient.

Dislocations of the Foot at the Calcaneo- and Scapho-astragaloid Joints, commonly called Dislocations of the Astragalus.

In the last-described dislocations, the astragalus maintained its normal relations with the other bones of the foot, and altered them only as regards the bones of the leg; in the dislocations we are now about to speak of, the astragalus retains its connections with the latter, but is no longer in normal relation with the former. Till a comparatively recent date, no distinction was made between this accident and the one next to be described, in which the astragalus is separated from the bones both of the leg and of the foot; but under the general term dislocation of the astragalus were included both these forms of injury. It is not therefore to be wondered at, that those who first recognized the distinction, and perceived that two different accidents had hitherto been confounded with each other, should not have adopted a uniform nomenclature in reference to the newly-discovered injury. [Mr. MacCormac (St. Thomas's Hospital Reports, N. S., vol. 3; American Journ. Med. Sciences, Oct., 1873, p. 489), recommends the following classification, premising that there are three distinct forms of displacement which should receive distinct names: 1. Dislocation of the foot, occurring at the tibio-tarsal joint. 2. Sub-astragaloid dislocation, when the astragalus maintains its connection with the leg, and the rest of the foot is dislocated (the form under consideration in the text). 3. When the astragalus is separated from all its connections—the only true dislocation of the astragalus.] Accordingly, it has been described under the following synonyms: (1) dislocation of the astragalus; (2) partial dislocation of the astragalus; (3) single dislocation of the astragalus; (4) dislocation of the head of the astragalus; (5) luxation sous-astragalienne; (6) luxation métatarsienne; (7) dislocation of the scaphoid and calcis from the astragalus; (8) dislocation of the os calcis and astragalus. In adopting a nomenclature which has not hitherto been employed to designate this injury, the writer has been influenced mainly by a desire that it should at once express the real nature of the accident, and at the same time not violate the rule which regards the distal part of the limb as that which is displaced. Both these conditions are more perfectly fulfilled by the title at the head of this section than by any of those previously employed. It may be objected, that it is only a part of the foot which is displaced, and therefore to call the accident a dislocation of the foot is not correct; but for this objection to be valid, it must first be shown that the foot deprived of a toe, or the hand of a finger, is thereby disentitled to its distinctive appellation.

The principal varieties of this dislocation are four in number, viz., two lateral, which are the most common; one back-

wards, which is very uncommon; and another forwards, which is still more rare. The chief lesions which are found in the simple dislocations are rupture, partial or complete, of the interosseous ligament between the os calcis and astragalus, and of the synovial capsules between these bones. The scapho-astragaloid ligament is also torn through, together with the lateral ligaments of the ankle-joint, sometimes on both sides, but more frequently on the one which is opposed to the direction of the displacement. Partial fractures of the astragalus, os calcis, or both bones, or of one or other malleolus, injury or rupture of some of the tendons, bloodvessels, or nerves, are occasionally met with in the compound varieties of this accident.

A question of some interest in connection with these displacements is, whether the scaphoid, with the rest of the foot, can be luxated from the head of the astragalus, the body of this bone retaining its connections with the os calcis through the unruptured interosseous ligament; or, to make use of the phraseology generally employed, whether the head of the astragalus can be luxated without its body undergoing displacement. Till the publication of M. Broca's memoir,[1] this form of injury was generally believed in; but that acute surgeon, arguing from the anatomical relations of the bones of the tarsus, especially those of the os calcis and cuboid, questions the possibility of its occurrence, and proves incontestably that some of the recorded examples were really luxations of the whole foot at the calcaneo-astragaloid joint, with rupture of the interosseous ligament, while others he considers had their origin in errors of diagnosis. Without doubting the frequency of diagnostic errors, most surgeons will probably be more disposed to admit with Malgaigne as "très possibles les subluxations sur le scaphoïde signalées par Boyer et Richerand, et même les luxations complètes de la tête de l'astragale avec un déplacement à peine sensible du corps de l'os sur le calcanéum."[2] Indeed, the possibility of such an injury must now be considered as placed beyond a doubt by a case recorded by Pollock, in which, in a well-marked dislocation of the foot inwards, the interosseous ligament was found to be unruptured.[1]

In the dislocation of the foot backwards (commonly called dislocation of the astragalus forwards), the head of the astragalus

Fig. 244.

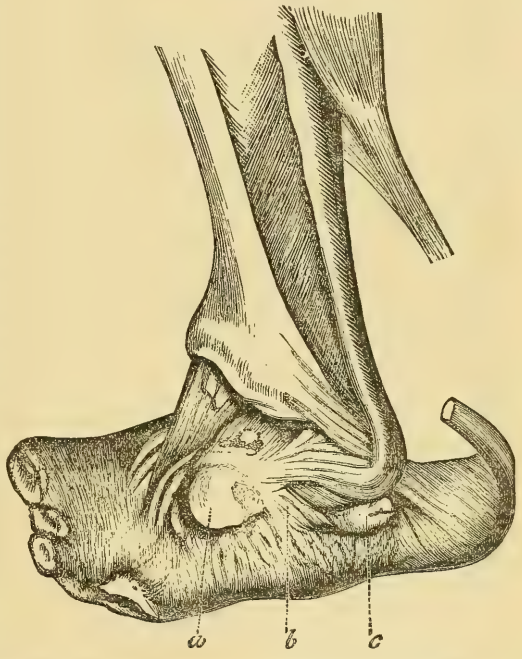


FIG. 244. Dislocation of the foot at the calcaneo- and scapho-astragaloid joints. The tendo-achillis is seen to have been divided, by which means the dislocation was reduced during life. After death the tarsus was put into the inverted position which it occupied at the time of the accident. *a*. The head of the astragalus displaced from its connection with the scaphoid. *b*. The interosseous calcaneo-astragaloid ligament, not completely ruptured. *c*. The posterior articular surface of the astragalus, marked by a slight fissure. (From the Museum of St. George's Hospital. Pollock's case.)

rests upon the instep, where it forms a tumor, projecting almost through the skin, the foot is somewhat extended and shortened in front of the leg, but elongated behind. Slight flexion and extension can be made, though attended with pain.

Perhaps the best example of this variety of dislocation is that published by Macdonnell, of which the following is an abstract. On August 6, 1838, Mr. Carmichael was riding at a brisk trot, when his horse suddenly fell. To prevent being pitched forwards, he threw himself back in the saddle, and strongly extended his legs to meet the ground. The shock of his descent was accordingly received upon the anterior extremities of the metatarsal bones, especially the metatarsal bone of the great toe of the right foot, which alone came to the ground. The following were the symptoms: "The toes were turned outwards, the inner edge of the foot forming an angle of about 30°

[1] Mémoires de la Société de Chirurgie, tome iii., p. 566.

[2] Op. cit., tome ii., p. 1031.

[1] Med.-Chir. Trans., vol. xlii., p. 39.

with its natural direction; the sole was slightly turned outwards, and the outer edge slightly elevated. The concavity of the tendo-achillis posteriorly was manifestly increased, and the heel lengthened. On grasping the soft parts between the tendo-achillis and tibia, we found the distance between these parts much greater than in the other foot. The absence of the hard projection, which would have been formed by the upper articulating surface of the astragalus, had it passed backwards with the other tarsal bones, was evident. The malleoli were perfectly defined. Below and before the inner there was a hard prominence, over which the skin was tense, formed by the inner surface of the astragalus brought into relief by the dislocation, and the slight eversion of the sole of the foot. Much the most striking part of the deformity consisted in a prominence on the dorsum of the foot. Immediately in front of the tibia it presented a flat surface broad enough to receive the finger, and from which there was an abrupt descent upon the anterior part of the tarsus. Over this projection, caused by the head of the astragalus, the integuments were so tense that it was evident a very small additional force would have driven it through the skin. Lastly, on taking the distance from the point of the internal malleolus to the extremity of the great toe with a tape-measure, I found it to be exactly an inch less than the distance between the same points in the left foot. We could detect no fracture. The foot could be flexed and extended, but it occasioned great pain."[1]

Reduction was attempted by making extension from the foot, and counter-extension from the knee, previously bent to the utmost; at the same time the heel was pressed forwards, and the astragalus and tibia backwards, the toes drawn inwards, and the outer edge of the foot depressed. These means failing, pulleys were applied, and the manipulation continued, and in about ten minutes, the pain having become unendurable, Mr. Carmichael made a violent effort, the pulleys were relaxed, and the reduction was effected at the same moment without noise.

Dislocation of the foot forward is exceedingly rare. Malgaigne could find but one example, which is recorded by M. Parise.[2]

It happened to a quarryman who, while at work, with his left foot resting on a block of stone, and his right on the ground, was thrown forcibly forwards by the falling of a mass of stone; the thigh being at the time strongly flexed on the trunk, the leg on the thigh, and the foot on the leg. The following were the symptoms: the foot was flexed on the leg; the projection of the heel had disappeared; and the extremities of the bones of the leg, with the astragalus, were directed to the posterior part of the calcaneum. As no crepitus could be elicited, the accident was presumed to be a dislocation; but the swelling and pain were so great, that a complete examination could not be made, and reduction was not attempted. Nine months afterwards the condition of the limb was as follows: the foot was flexed at a right angle with the leg, its point inclined inwards, and its inner border slightly depressed; it was elongated in front of the bones of the leg, and the projection of the heel was completely effaced. At the level of, and a little below the malleoli, posteriorly, was a bony projection, which pushed backwards the tendo-achillis beyond the heel. Above this projection was another less marked, formed by the posterior and inferior margin of the tibia; the malleoli were not separated from each other, nor did they present any traces of fracture. The extensor tendons of the toes were stretched over the instep, and beneath these on the outer side was a projection, which appeared to be the head of the astragalus, and immediately in front of this a depression. Flexion and extension of the ankle-joint existed to a limited extent.

Dislocation of the foot sideways.—The lateral dislocations of the foot at the calcaneo-astragaloid joint are most frequently compound and incomplete; that is, the astragalus still rests on a portion of the os calcis, and is not placed at its side as in the complete dislocations. These dislocations are most frequently brought about by forced movements of adduction or abduction, and the foot retains very nearly the position in which it was thrown by the accident; but in some cases it has been forced from under the astragalus without any deviation of its borders or surfaces, as happened in a case reported by Mr. Hancock,[1] in which the foot was thrown outwards; and in another case of Mr. Paget's, in which it was thrown inwards. The symptoms of a luxation outwards are, abduction of the foot, its outer border being raised, and its inner resting on the ground. The outer malleolus is buried in the fossa caused by the eversion of the foot, and the inner malleolus and the head of the astragalus project unnaturally inwards. In the complete dislocation this projection will be greater, and, in addition to these symptoms, there will be a shortening of the limb, and the extremity of the inner malleolus will be placed nearer to the sole of the foot. In thirteen examples of this injury collected by Broca, nine were compound, and in six the fibula was broken.

In the dislocation inwards, the foot is inverted and its inner border raised, resembling the varus form of club-foot. The head of the astragalus and the outer malleolus project beyond the outer border of the foot, and a deep depression exists below. On the inner side of the foot, an elongated projection formed by the inner border of the calcaneum completely masks the inner malleolus. The scaphoid bone can be felt nearer to the os calcis than natural, and thus the inner border of the foot is shortened and somewhat concave, while the outer is lengthened and unnaturally convex. The tibia and fibula are unbroken.

[1] Dublin Journal, 1839, vol. xiv., p. 235.
[2] Annales de la Chirurgie, 1845, tome xiv.

[1] Lancet, 1844, vol. ii., pp. 35, 70, and Med.-Chir. Trans., vol. xlii., p. 46.

Two cases of this dislocation have been described by M. Letenneur,[1] and two by M. Malgaigne.[2]

Diagnosis.—There are several injuries with which dislocations of the foot at the calcaneo-astragaloid joint may be confounded, the principal of which are the following:

1. Dislocations at the ankle-joint.
2. Fractures of the tibia just above the ankle-joint.
3. Fractures of the astragalus in a horizontal or oblique direction.
4. Dislocations of the astragalus properly so called.

1. From the lateral dislocations of the foot at the ankle-joint they may be distinguished by the projection of the head of the astragalus in front of the bones of the leg, and by the persistence of the movements of flexion and extension; while fracture of the malleoli, which is the rule in dislocations at the ankle, is the exception in the corresponding sub-astragaloid dislocations. In the antero-posterior luxations at the ankle, the upper pulley-like surface of the astragalus will project either in front of or behind the leg-bones, and the whole limb will be shortened; while both these signs will be absent in the sub-astragaloid dislocations. 2. Fractures of the tibia just above the ankle-joint, with displacement of the foot backwards, also bear some resemblance to the sub-astragaloid dislocations of the foot in the same direction, but may be distinguished from them by the same signs as distinguished the luxation without fracture just given, and by the existence of crepitus; to which we may add that the dislocation consequent on fracture is rarely or never complete, and the lower sharp ridge of the broken bone can be felt projecting beneath the skin. 3. Fractures of the astragalus, when occurring in a horizontal or oblique direction, are generally accompanied with distortion, resembling somewhat the dislocations we are treating of; the foot with the lower fragment of the astragalus being carried in one direction, and the leg with the upper fragment in the opposite. These accidents, however, are rare, and, in all the recorded examples met with, were compound; so that the nature of the lesion was manifest; but in a simple fracture of this nature, the diagnosis might probably be established by the crepitation, and by the absence of the projection caused by the head of the astragalus. 4. Luxations of the astragalus from all its connections are unquestionably the accidents which have been most frequently confounded with the sub-astragaloid dislocations; but the shortening of the leg, produced by the approximation of the tibia to the os calcis, the relation of the head of the astragalus to the malleoli, and the loss of motion of the ankle-joint, are sufficient to distinguish them.

Treatment.—What cannot fail to have struck any one who has looked over the published cases of this dislocation, and that of the astragalus with which it has been confounded, is the ease with which some of these have been reduced, and the extreme difficulty, and even impossibility, of its reduction in others. These difficulties are owing to the following circumstances. 1. The posterior edge of the astragalus may become wedged in the fossa between the articulating facets of the os calcis. This has happened in several instances, and has hitherto presented an insuperable obstacle to reduction: thus in M. Roux's case of dislocation outwards, in which amputation was performed, Nélaton found the head of the astragalus resting on the inner surface of the scaphoid bone, while the deep fissure between its two inferior articulating surfaces received a portion of the sharp margin which surrounds the articulating cavity on the posterior surface of the scaphoid; the posterior edge of the astragalus was also engaged in the fossa which separates the two superior facets of the calcaneum.[1] 2. The head of the astragalus may be driven against the tendon of the tibialis posticus muscle, and either rupture it, or escape above or below it. In the last case, the neck of this bone will be firmly constricted between the tendon and the calcaneo-scaphoid ligament; and extension made to reduce this form of dislocation will be the most effectual means of preventing it from taking place. 3. In the dislocation inwards the head of the astragalus will rupture or push before it the extensor tendons on the dorsum of the foot, and no obstacle will be presented by them to the reduction; but the scaphoid and anterior part of the foot are drawn towards the heel, so that the space between the scaphoid and os calcis, occupied normally by the under and inner part of the head of the astragalus, is obliterated by the action of the same muscles as are engaged in the production of talipes varus; chiefly the gastrocnemius and soleus, and the two tibial muscles. The dislocation forwards is so rare that no dissections, I believe, have been made to show what were the obstacles to reduction; but looking at the form of the os calcis, it would seem highly probable that it was due to the outer border of the posterior facet of the calcis being engaged in the interarticular fossa on the under surface of the astragalus. With our present knowledge, then, of the chief circumstances which have hitherto so

[1] Rev. Méd.-Chir., 1854, tome xii., p. 19.
[2] Malgaigne, op. cit., tome ii., p. 1044.

[1] Bull. de la Soc. anat., 1835, tome x., p. 38.

frequently baffled the best attempts to effect reduction of these dislocations, it would seem expedient in all cases of simple luxation which have not yielded to moderate extension and manipulation, to divide subcutaneously one or more of the tendons of those muscles which offer the greatest resistance to our efforts. In all, reduction would probably be facilitated by division of the tendo-achillis, and in the lateral displacements one or both tibials may also require division.[1] If these means fail, all further operative measures should be abandoned for the moment, and only again had recourse to if the integuments slough, and the exposed astragalus becomes necrosed, when a part or the whole of this bone may be removed with very little risk to the patient. [Mr. MacCormac, in the article previously mentioned, advises a similar plan of treatment, and records four cases of the injury.] In the dislocations, compound from the beginning, reduction should be attempted, as in the simple forms; but in the event of failure, the astragalus should be removed without delay.

Dislocations of the Astragalus properly so called.

These are the dislocations to which Boyer has applied the term double, on account of the separation of the astragalus from both the tibia and os calcis. According to Malgaigne, these are more common than the sub-astragaloid dislocations, while Pollock believes them to be the most rare of all dislocations implicating the bone. Unfortunately, we do not at present possess sufficiently reliable data on which to determine their relative frequency. The astragalus may be displaced in the same directions as it occupied in the last-described luxations, viz., forwards, backwards, and laterally; to which must be added certain peculiar and rare displacements of the bone, in which it becomes rotated, to a greater or less extent, on one or the other of its axes. Thus it has been found rotated from a quarter to half a revolution on its antero-posterior or long axis, so as to bring the upper and lower surfaces of the bone to look sideways, or even completely to reverse their normal position; it has also been found rotated around its vertical axis, the head of the bone looking inwards, and the outer surface of its body forwards. Or, more remarkable still, these two forms of luxation have been combined, as in a case related by Thierry, in which the head of the bone was directed backwards, and the posterior extremity of the bone forwards and outwards. At the same time it was so rotated on its antero-posterior axis that the trochlea looked inwards, and the tibia rested on the inner side of its body, which was upwards, its inner edge fitting exactly into the angle formed by the malleolus with the rest of the mortise.[1]

Dislocation of the astragalus forwards.—In this form of displacement the astragalus is thrown either directly forwads, or, what is more common, with an inclination of its head to the inner or outer side. [M. Rigal (La France Médicale, August 7, 1875, Philadelphia Med. Times, September 11, 1875, p. 790) reports a case of this kind, where reduction was successfully accomplished, and the patient recovered entirely in two months. He says that of 93 cases reported, which were complete luxations of the astragalus "not compound, this was only the twenty-seventh time that reduction had been effected."] The symptoms do not differ as regards the position of the astragalus with reference to the other bones of the foot from those which characterize the dislocations described in the last section, but the relation of the displaced bone to the bones of the leg offers an important point of difference by which they may be distinguished. Thus the astragalus being thrown forwards from underneath the tibia, forms a projection in front of it; while the latter, now resting on the os calcis, appears sunk into the dorsum of the foot, and the movements of the ankle-joint are of course annihilated. In some of these dislocations forwards, the head of the astragalus has been thrown so much inwards and downwards as to bring the long axis of the bone into a line with that of the tibia, and so to appear as if it were a continuation of that bone. The position of the foot is always found to vary with that of the astragalus, and to be more or less everted or inverted, according as the bone is thrown towards one or the other side.

Dislocation of the astragalus backwards is a somewhat rare accident, but two excellent examples of it have been published by Mr. Benjamin Phillips, in the Medical Gazette of 1834, vol. xiv., one of which is here transcribed.

"Mr. G. was driving out in a phaeton, when the horse became unmanageable, and the reins broke. Mr. G. threw himself from the carriage, with the intention of stopping the horse; he alighted upon his feet, but immediately fell forward to the ground. The kind of injury which had occurred was immediately apparent by the remarkable projection which was presented just above the heel. The tendo-achillis was pressed out by the displaced astragalus, so as to form an angle of 40°, and at

[1] See Pollock, Med.-Chir. Trans., vol. xlii.

[1] Examples of these forms of injury have been recorded by Laumonier (Journal de Fourcroy, 1791, tome ii., p. 40); Foucher (Revue méd.-chir., 1845, tome xvii., p. 203); Dupuytren (Annuaire méd.-chir. des Hôpitaux de Paris, 1819, p. 28); Turner (Transact. Provin. Med. and Surg. Assoc., vol. ix., p. 417).

one point the bone had reached so near to the surface that vesication was produced directly over it. The anterior part of the foot appeared shortened, and a projection was presented anteriorly by the inferior extremity of the tibia. There was very little ecchymosis, and it was not at all evident upon what portion of the foot he had rested on coming to the ground. It appeared probable that the foot was suddenly and forcibly flexed, because in that movement the anterior border of the articular surface of the tibia meets the neck of the astragalus, which arrests the movement of flexion before it has proceeded far enough to produce luxation of the foot upon the leg." This conjecture of Mr. Phillips is rendered highly probable by the mode in which the luxation was produced in another case, which he describes in the same journal. The gentleman was playing at cricket, and, while running very rapidly after the ball, a gutter which was in his course was not observed. The toes rested on the further side of this gutter, while the heel was jammed directly into it, and he fell forward. The appearance of the limb in these two cases was very similar. [An extremely interesting case is reported by Dr. Cheever in the Boston Med. and Surg. Journal, August 26, 1875, where the diagnosis was fracture of the astragalus at its neck, with a dislocation of the whole body of the astragalus, inwards and backwards. Extension and counter-extension, flexion, pressure and tenotomy of the tendo-achillis, the tibial muscles and the long flexor, all proved unavailing. The leg was immovably fixed upon a curved Pott's splint, and the patient finally recovered with a tolerably useful foot.]

The dislocated astragalus, instead of being thrown directly backwards, is sometimes found on the inner or outer side of the tendo-achillis, between this and one or other of the malleoli. An example of the displacement backwards and inwards, which was reduced, occurred at University College Hospital, in the year 1839, and is reported in the July number of the Lancet of that year. A compound dislocation of the astragalus, backwards and outwards, which could not be reduced, and in which the bone was therefore extracted, is recorded by Turner, in his collection of cases.[1]

Dislocation of the astragalus inwards and outwards.—These displacements cannot be complete without being at the same time compound, when the nature of the injury is thus rendered manifest. Even in the incomplete luxations, if the bone be not reduced, sloughing of the soft parts over the projecting astragalus takes place subsequently, and reveals the nature of the displacement. It is difficult to imagine how either of these luxations can take place without a fracture of the malleoli; yet Boyer assures us, that in a case of dislocation of the astragalus inwards, to which he was called, there was no fracture of any bone, nor any separation of the tibia from the fibula. On reading his description of the case, it would appear to be a dislocation of the foot outwards, at the calcaneo-astragaloid joint, while at the same time the astragalus was rotated on its long axis, so as to place its upper or trochlear surface inwards, and its outer surface upwards. Thus it can scarcely be called a dislocation inwards, inasmuch as the bone did not completely leave the mortise which is formed for it by the tibia and the fibula. Two other very similar cases have been recorded by Aubray[1] and Robert[2] in both of which the bone had undergone the same rotation on its axis; but the displacement inwards was greater, the trochlear surface projecting in this direction beyond the inner malleolus.

Treatment.—The reduction of a complete dislocation of the astragalus, without division of the tendons which pass from the leg to the foot, would appear at first sight to be wellnigh impossible; and though several such cases have been published, it is highly probable that some of them at least were instances of partial and not of complete luxation. This difficulty of reduction is owing to the obliteration of the space normally occupied by the astragalus, through the action of the powerful muscles which pass from the thigh and leg to the foot. If moderate extension and counter-extension under chloroform, together with manipulation, fail, the tendo-achillis should be divided, and this likewise failing, the bone had better be left in its abnormal situation, and no immediate attempts made to remove it. The propriety of leaving the bone, instead of removing it in the first instance, was strongly insisted on by Sir A. Cooper; and the judiciousness of this practice has been fully proved by the more recent researches of M. Broca, who has shown that in 36 cases of irreducible simple luxation of the astragalus, in which immediate extraction of the bone was performed, 9, or one-quarter, were fatal; while in 43 irreducible cases in which no primary operation was performed, there were only 2 deaths. Of the remaining 41 cases, amputation was performed in 2; and extraction of the bone, after it had become exposed by the sloughing of the integuments, in 16; all of which recovered: while no operation of any kind was required in 23, the patients recovering with a useful limb, though of course with some deformity and lameness.[3] The practice to be pursued in compound luxations of the astragalus differs from that recommended in the compound sub-astragaloid dislocations, for the reason that the bone is more completely separated from its connections, and that the space which it naturally occupies is obliterated by the ap-

[1] Loc. cit.

[1] Aubray, Journ. de Méd., 1771, tome xxxvi., p. 351.

[2] Robert, Gazette des Hôpitaux, 1846, p. 384.

[3] Gazette des Hôpitaux, 1852, p. 371.

proximation of the tibia and the calcis. The first would render it more liable to death, and the second would increase the difficulty of returning it. If we add to these two circumstances the fact of there being an open wound communicating with the isolated and detached bone, it seems more than probable that, even if reduction were effected, its vitality would be so far impaired as to render its subsequent extraction necessary, while the irritation it would be likely to set up might jeopardize the limb, or even the life of the patient. Under these circumstances, the most proper and safe course is to remove the bone in the first instance, without making any attempt at reduction.

Dislocation of some of the other Tarsal Bones.

Dislocation of the os calcis, etc.—M. Broca, after a careful analysis of the recorded cases of this dislocation, decides that the evidence in favor of them is not conclusive.

Malgaigne agrees with Broca, so far as the cases he has adduced as evidence are concerned, yet cites two instances which came under the charge of M. Jourdan, at the Hôtel Dieu of Marseilles, which, he considers, establish beyond doubt the possibility of this accident taking place. In one of these the relations of the astragalus, scaphoid, and leg bones, and the movements of flexion and extension of the foot, were perfect. The os calcis projected considerably beneath and external to the outer malleolus, and its anterior articular process was separated from the cuboid. The luxation was caused by a heavy piece of wood falling on the foot from a height; and M. Jourdan easily reduced it by making pressure on the foot and os calcis in opposite directions.[1] In 1847 Mr. Canton published in the Lancet of May 15, "An account of the dissection of an unusual form of displacement of the astragalus," but which Malgaigne considers an example of dislocation of the calcaneum outwards.

Dislocations of some of the other tarsal bones are occasionally met with; thus Burnett has described, in the Medical Gazette for 1837, vol. xix., p. 221, the case of a gentleman who, in taking a leap while fox-hunting, dislocated the scaphoid bone from its connections with the cuneiform bones. Burnett found a wound three inches in length over the instep, through which the scaphoid and astragalus protruded, the three facets of the former bone being directed forwards and outwards. By making steady pressure on this bone for fifteen minutes it was reduced, the wound healed, and the patient recovered the free use of the foot. Cases have been recorded by Piedagnel, Walker, and others, in which the bone has been separated from the astragalus as well as from the cuneiform bones.[2]

Dislocations of the cuneiform bones.—Two forms of luxation of the internal cuneiform bone have been met with; in one it is separated from the scaphoid in company with the first metatarsal bone; in the other it is separated from all its articulations, and is thrown upwards and inwards. The three bones are also sometimes luxated together upwards, and are reduced by pressure without much difficulty.

Dislocations of the first row of tarsal bones from the second row, or of the os calcis and astragalus from the cuboid and scaphoid bones.—The reality of this accident is somewhat problematical, and has not yet been verified by dissection. Its assumed existence rests chiefly on the evidence of Petit and Sir A. Cooper; the first of whom affirms that he had met with two cases, but gives no description of the symptoms, and merely contents himself with the following brief remark: "Cette maladie se connaît par la seule difformité, elle indique le côté où les os se trouvent logés."[1] Sir A. Cooper does not profess to have seen the case he describes, which is given on the authority of the students of Guy's Hospital, who had reduced the displacement before he saw it. "The calcis and astragalus remained," we are told, "in their natural situations, but the forepart of the foot was turned inwards upon these bones. The appearance was so precisely like that of a club-foot, that they could not at first believe that it was not a natural defect of the kind."[2] Another example of this injury has been recorded by Liston.[3] A boy, aged fourteen, fell from a height of forty feet, and alighted on the extremity of the right foot. The scaphoid and cuboid bones, it is stated, were dislocated upwards, and the foot was half an inch shorter than the other. Reduction was not attempted, but the patient left the hospital in three weeks able to stand on the foot.

Dislocations of the Metatarsal Bones.

One or more of these bones are sometimes displaced, or the entire range may be thrown upwards, downwards, outwards, or inwards, the first direction being the most frequent. Some rare examples have been seen in which contiguous bones have been thrown in opposite directions; the three first, for example, being thrown downwards, and the fourth upwards. Although these dislocations can only be occasioned by great violence, they are rarely compound; they are most frequently caused by falls on the toes, or by force directed on the anterior part of the foot from above downwards, or laterally. The luxations upwards and down-

[1] Malgaigne, tome ii., p. 1069.
[2] Journal univ. et hebdom., 1831, tome ii., p. 208; The Medical Examiner, 1851, p. 203.

[1] Petit, Maladies des Os, 1723, tome i., p. 321.
[2] Cooper, op. cit., p. 336.
[3] Liston, Practical Surgery, p. 140.

wards are readily diagnosed by the shortening of the foot, without a corresponding elongation of the heel, and by the projection and depression on the instep. Dr. Smith, of Dublin, who has given one of the best accounts of the upward dislocation

Fig. 245.

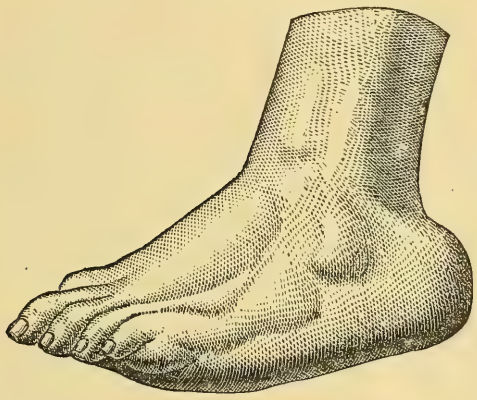


FIG. 245. Dislocation of the metatarsus. (After R. W. Smith.)

of these bones,[1] calls attention to the peculiar alteration in the form of the sole of the foot, which, instead of presenting its natural concavity, becomes convex both in its antero-posterior and transverse diameters. The lateral displacements are readily distinguished by the projection at the inner or the outer border of the foot. In an analysis of twenty-nine cases of these tarso-metatarsal dislocations, Dr. Hitzig found thirteen were of single bones, and sixteen of the entire metatarsus. It would seem also, that unreduced dislocations of the entire tarsus in a vertical direction, give rise to less inconvenience than the lateral displacements. Recent dislocations are best reduced by manual extension and counter-extension, with pressure of the thumbs on the displaced bone, under chloroform.[1]

Dislocations of the phalanges are rare. Of twenty-two cases in which the first row were dislocated, Malgaigne states that nineteen were of the great toe, and three of all the toes at once. The displacements are always upwards, and may be complete or partial, and are generally compound. There is a certain analogy between the luxation of the first phalanx of the great toe and that of the corresponding phalanx of the thumb, and a similar difficulty is experienced in its reduction; this, it has been conjectured, is owing to the resistance of the internal lateral ligaments and the tendons of the short and long flexor muscles. Reduction has sometimes been effected by traction only, but at other times all means, even dividing the internal lateral ligaments and the flexor tendons, have failed. Dislocations of the second row of phalanges are so rare that Malgaigne could find but two examples of the accident on record; one was a compound dislocation affecting the great toe, and the other the third toe; both were returned. These accidents, he states, are almost peculiar to jockeys, and arise from falls from horseback with the foot underneath the animal. They have also been occasioned by the passage of carriage-wheels over the foot.

[1] Smith, op. cit., p. 226.

[1] New Syd. Soc. Biennial Retrospect, 1865–6, p. 273, from Berliner Klin. Wochenschrift, vol. ii., p. 39–42, 1865.

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